# THE JANUARY SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL



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# THE SCIENTIFIC MONTHLY

JANUARY, 1938

## THE BOTANICAL GARDEN AT RIO DE JANEIRO

By Dr. F. LAMSON-SCRIBNER
WASHINGTON, D. C.

Among the many and altogether charming lures of the Capital City of Brazil is its Botanical Garden—Jardim Botanico do Instituto de Biologica Vegetal—located amidst wonderfully picturesque surroundings in a region where it is always summer. All the warmer countries of the world have contributed to its collections of living plants, interesting alike to the botanist and the traveler. The wonderful flora of Brazil is richly represented with the characteristic species of the Valley of the Amazon predominating.

Ever since the establishment of this garden in 1806, it has been under the care and direction of eminent and enthusiastic botanists, who looked upon plants as living things abounding in interest.

[1] Photographs by the author.

THE MAIN ENTRANCE.

THROUGH THE MODEST PORTALS OF THE MAIN ENTRANCE WITH THEIR RATHER PLEASING LODGES ON EITHER SIDE, ONE ENTERS BRAZIL'S WORLD-FAMOUS BOTANIC GARDEN TO MEET ITS SPLENDID COLLECTIONS OF TROPICAL PLANTS FROM THE TREASURES OF THE BRAZILIAN FORESTS TO THE VALUABLE PRODUCTS OF THE LANDS OF THE ORIENT—INDIA, JAPAN, AUSTRALIA, AFRICA AND ISLANDS OF THE SOUTHERN SEAS, ALL HAVE CONTRIBUTED TO THE INTEREST AND FAME OF THE VAST ASSEMBLAGE OF LIVING PLANTS NOW HERE UNDER CULTIVATION.

A SECTION OF THE OVERHANGING WALK

ALONG THE ANCIENT OPEN AQUEDUCT THAT YEARS AGO CAUGHT THE WATERS FROM THE MOUNTAIN SLOPE TO SUPPLY THE YOUNG CITY OF RIO. BEHIND THE OBSERVER STANDING ON THE WALK, IS A SHORT SECTION OF THIS AQUEDUCT CUT IN THE SOLID ROCK. FAR TO THE RIGHT OF THE OBSERVER WE SEE THE RUGGED, FLAT-TOPPED SUMMIT OF GAVEA—THE ''CROW'S NEST''—BEFORE HIM LIES THE EXPANSE OF THE ATLANTIC WHILE ALMOST BENEATH HIS POINT OF VIEW AT THE FOOT OF THE STEEP MOUNTAIN SIDE SUPPORTING THE OVERHANGING WALK LIES THE BEAUTIFUL GARDEN OF RIO DE JANEIRO, A VERY LOVELY SPOT WITHIN THE TROPICS THAT NOW IS A SOURCE OF PLEA-

They delighted in watching the reactions of the plants towards each other in communities, their response to changes of soil conditions in their new surroundings and to the effect of variations in temperature, food supply, and the like, together with possible modifications in their usefulness or economic values under cultivation.

The laying out of the grounds and arrangement of the trees and flowers are pleasing, while the naming of the many avenues, called "*Aléas*" in Rio, and the placing of attractive monuments to commemorate those botanists who helped in the development of the garden add a further interest that includes an expression of a merited appreciation of their work.

In 1932 the garden was incorporated with the Biological Station of Itatiaya and other scientific agencies. The organization now embraces with the Biological Station and Botanical Garden, the Library, Herbarium, agricultural entomology, phytopathology, agricultural genetics and ecology. Dr. Paulo de Campos Porto is director of the entire organization, reporting directly to the Secretary of Agriculture.

Other activities recently undertaken by the director are courses of instruction in botany bearing especially on the modification of plants due to changes of habitat, and occasional exhibitions of plants grown in the garden, possessing special features of attraction or public interest.

In 1935 the garden contained nearly 140 acres, with about eighty acres of land under cultivation. The collections, to which additions are constantly being made, contain species representing 196 families.

My first visit to this garden was in 1910, during a brief stop at Rio while en route to Buenos Aires, Argentina. Years later I was again in Brazil, remaining at Rio for nearly a year, and during this period visited the garden many times. The days were always too short when espying lovely flowering plants and delicately plumed ferns along secluded paths and fascinating glens, or when, in more restful moods, I leisurely strolled through quiet avenues bordered by massive palms of towering height, or shaded by leafy trees glorified at times by fragrant blooms.

Here and there standing, singly or in groups, were trees that recalled familiar pictures in old-time geographies. There were tea plants and coffee trees from China and Java; the traveler's-tree from Madagascar; the beautiful mango, whose delicious fruit is now common in the markets of our larger cities; the breadfruit tree, and its relative the Jack-fruit or "Jacka" (*Arctocarpus integrifolius*), the strangler tree (*Ficus Benjamina*), named "strangler" because of its habit of sending out many aerial roots or *lianes*, that in their growth touch and coil tightly around the trunks of nearby trees, finally strangling them. There were the more common date and coconut trees, two of the 160 or more kinds of palms in the garden's collection; and several specimens of the great silk cotton tree (*Ceiba pentandra*), remarkable for its great height and the huge sustaining abutments at its base. The section devoted to bamboos—those wonderful giant grasses that in India are classed with the forest trees—occupies a place around Leandro Lake, a charming center of interest to visitors.

There are small streams, cascades, tiny lakes and pools which are the home of pickerel weed (*Pontederia cordata*), several species of pond lilies (Nymphaea), and the royal *Victoria regia;* lotus plants, papyrus, the ancient paper plant from the shores of the Nile, and other aquatics, all of which added beauty and interest to the landscape. There were nearly six thousand kinds of living plants here from many countries, every species of some economic or scientific in-

PALMS ALONG THE GARDEN FRONT.

PASSING THROUGH THE PORTALS WE NOTE A "PARTING OF THE WAYS"—FOUR GREAT AVENUES RADIATING FROM THE ENTRANCE, THE MAIN ONE GOING DIRECTLY ACROSS THE GARDEN. THIS IS THE "CENTRAL AVENUE OF PALMS." IT EXTENDS IN A NORTHWESTWARD COURSE ACROSS THE GARDEN TO ITS LIMITS AT THE BASE OF THE HILLS THAT FORM THE WESTERN BOUNDARY TO THE GARDEN AREA. *Aléa Custodio Serrão* LEADS FROM THE ENTRANCE WESTWARD TO THE "MOTHER PALM," AND MONUMENT TO D. JOÃO VI. BY WHOM THE GARDEN WAS DEDICATED IN 1808. A BEAUTIFULLY TREE-BORDERED AVENUE EXTENDS DUE NORTH TO LEANDRO AVENUE. INSIDE THE GARDEN WALL AND ALONG ITS FRONT IS ANOTHER PALM-BORDERED AVENUE 2,000 FEET LONG THAT IS BISECTED WHERE IT PASSES THE MAIN ENTRANCE. IT IS THIS BEAUTIFUL AVENUE THAT FIRST ATTRACTS THE VISITOR COMING OUT RUA JARDIN BOTANICO FROM THE CITY.

THE FAMILY GROUP.

NEARLY ONE HUNDRED AND SEVENTY SPECIES OF PALMS ARE RECORDED AS BEING CULTIVATED IN THE BOTANICAL GARDEN AT RIO. THOSE WHICH APPEAR IN THE "FAMILY GROUP" ILLUSTRATE TO SOME EXTENT THEIR VARIED GROWTH AS WELL AS THEIR BEAUTY AND THE MAJESTY OF SOME OF THE TALLER SPECIES. THE FOREGROUND MAKES A FITTING BASE FOR THE TOWERING PALMS THAT EXTEND ACROSS THE SCENE.

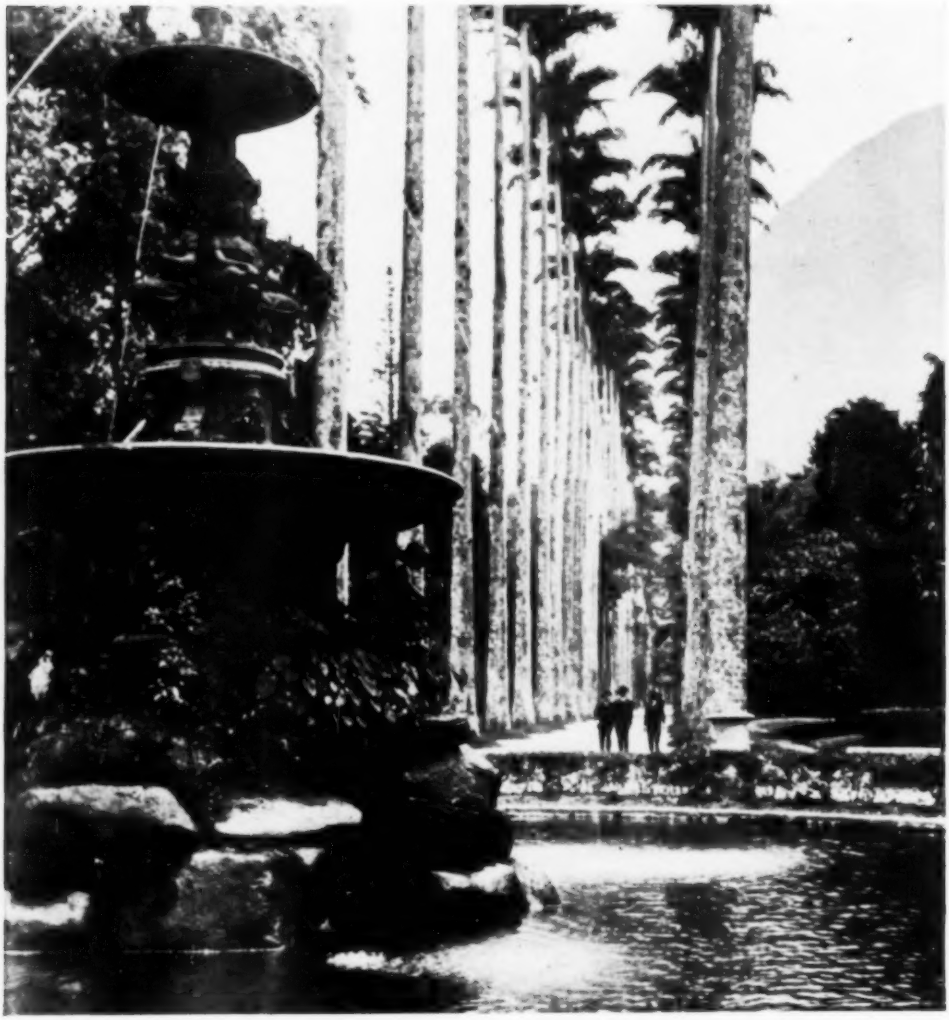
terest. To stand in the midst of such a vast assemblage from the plant world of the tropics was a memorable event in the life of one coming from the far rocky hills of Maine.

It is a short but very delightful ride to the Botanic Garden from the center of the city by the Park of Paris, through Rio's most beautiful residential section along Avenida Beira Mar and the curved shore of Botofogo Bay, then close under the peak of Corcovado, a granite mountain 2,310 feet high standing on our right, to Botany Street (*Rua Jardim Botanico*) and the main entrance to the garden itself. The approach to this entrance is heralded by an Avenue of Brazil's royal palms running parallel with the street for two thousand feet, a thousand feet on either side of the portals, facing Lagoa Rodrigo de Freitas and the Atlantic Ocean. These palms, although of comparatively recent planting, are already 100 feet high and beautifully symmetrical in form and even growth. Few gardens have a more attractive entrance or present within their gates larger or more interesting collections of plants from tropical regions.

We will now illustrate some of the landscape features of scenic interest and present a number of individual subjects, with captions, showing in a general way, their special attractions.

There are a dozen or more avenues that are bordered by interesting trees. They are quite a feature in the garden and add much to its character and beauty.

The central avenue of those radiating



ALLEGORICAL FOUNTAIN.

AT THE INTERSECTION OF LEANDRO AND RODRIGUES AVENUES. THE GREAT CENTRAL PALM AVENUE BORDERED WITH A DOUBLE LINE OF MASSIVE PALMS FROM THE ISLANDS OF THE CARIBBEAN SEA PLANTED HERE ONE HUNDRED AND THIRTY YEARS AGO. NO BOTANICAL GARDEN OFFERS A MORE INSPIRING SCENE, AND NONE HAS BEEN MORE FREQUENTLY PICTURED AND DESCRIBED. THE BEAUTIFUL FOUNTAIN HAS MANY DECORATIVE FIGURES, INCLUDING ALLEGORICAL PRESENTATION OF MUSIC, POETRY, SCIENCE AND ART.

LEANDRO AVENUE.

IN ITS NORTHERN SECTION, BEYOND THE ALLEGORICAL FOUNTAIN, THERE IS IN THE FOREGROUND A SIMPLE FOUNTAIN, OF WELL-KNOWN DESIGN, BEYOND WHICH IT IS BORDERED BY A SPLENDID GROWTH OF *Michelia champaca*, FROM INDIA. THIS TREE IS A CLOSE RELATIVE OF OUR WELL-KNOWN MAGNOLIAS AND IS SOMETIMES CULTIVATED IN THE FAR SOUTH. CORCOVADO FORMS A PLEASING BACKGROUND TO THE SCENE.

MONUMENT DEDICATED TO THE MEMORY OF FREI LEANDRO DO SACRAMENTO, 1762–1809.

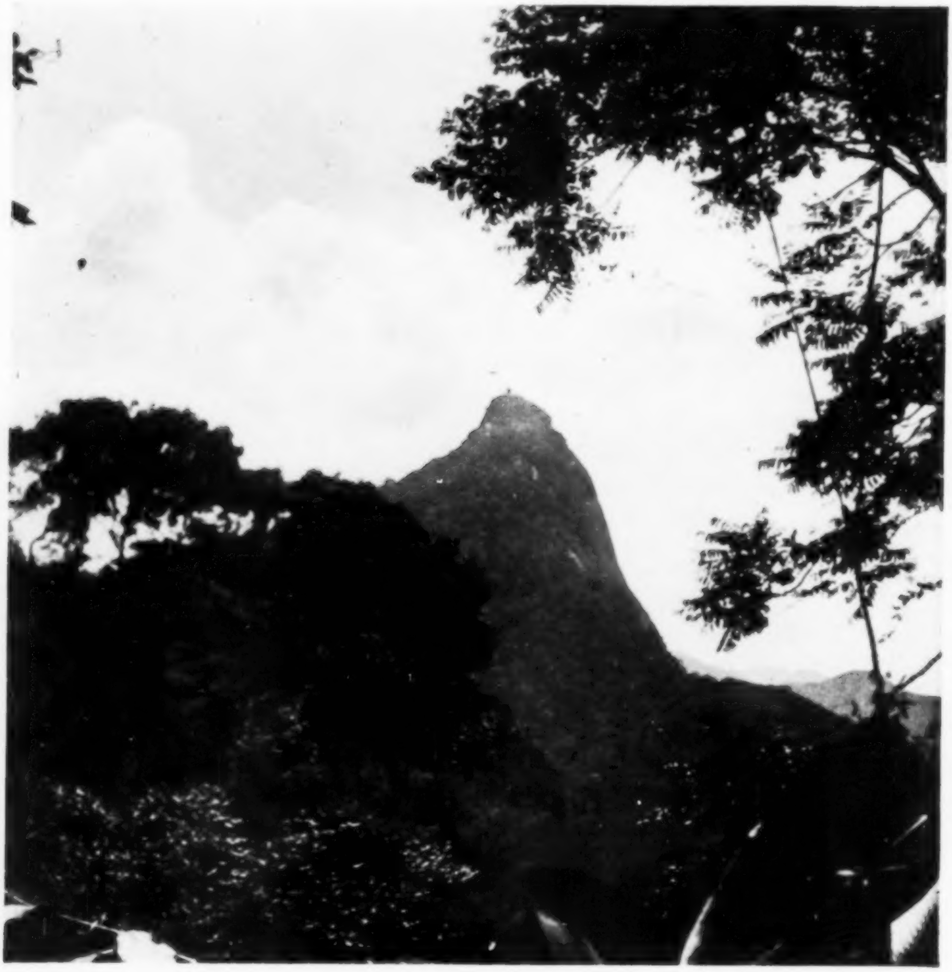
FREI LEANDRO WAS AN EMINENT BRAZILIAN NATURALIST AND WRITER ON BRAZILIAN PLANTS. THIS IS AN OCTAGON MONUMENT THAT SHELTERS A FINE BUST OF LEANDRO BENEATH WHICH IS A BRIEF INSCRIPTION DEDICATED TO HIS MEMORY. IT IS ON A SLIGHT ELEVATION CLOSE BY LAKE LEANDRO. THE MOUND IS COVERED WITH INTERESTING PLANTS, INCLUDING A FINE GROWTH OF *Andropogon squarrosus*, WELL KNOWN FOR THE PLEASING FRAGRANCE OF ITS ROOTS THAT YIELD A VALUED PERFUME.

LOOKING ACROSS LEANDRO LAKE.

THE OCTAGONAL MONUMENT HERE OCCUPIES THE CENTER OF THE PICTURE. MASSES OF PONTEDERIA OR PICKEREL WEED, COARSE FERNS, THE ARROW-TOPPED UVA GRASS (GYNERIUM SAGITTATUM), THE TRAVELER'S TREE, WITH ITS BANANA-LIKE LEAVES ARRANGED LIKE A WIDE-SPREADING FAN, AND THE TALL PALMS ACROCOMIA INTUMESCENS, ONE ON EACH SIDE OF THE MONUMENT, GO TO MAKE UP THE PICTURE.

from the main entrance, and extending directly across the garden, is the famous "*Aléa Barbosa Rodrigues,*" a "Street of Palms," bordered by a hundred and fifty royal palms of Brazil (*Roystonia oleracea*), whose cylindrical, branchless trunks are like gargantuan columns, gray, smooth and straight, each surmounted by a regal crown of widely spreading emerald green, plumose leaves ever reaching upward to bask in the brilliant light of a tropical sun.

Midway down this central avenue, where it intersects at right angles Leandro Avenue (*Aléa Frei Leandro*), is a large circular pool in which stands an interesting, two-basin, allegoric fountain of ancient design, about 20 feet high. Sitting around the central column above the larger basin are four allegorical figures representing Music, Poetry, Science and Art. When in full operation with its many jets of water spouting outward in all directions from among the numerous figures and cascading over the broad basins, the view is beautiful. The base



THE SUMMIT OF CORCOVADO,

A MOUNTAIN 2,310 FEET HIGH WHICH WE PASS ON OUR RIGHT ON THE WAY TO THE BOTANIC GARDEN FROM THE CENTER OF THE CITY. UPON THIS SUMMIT NOW STANDS A MONUMENT, OVER 100 FEET HIGH, OF CHRIST THE REDEEMER, THAT CAN BE SEEN FROM FAR DISTANT POINTS ON ALL SIDES OF RIO DE JANEIRO AND FROM FAR OUT TO SEA. THIS MOUNTAIN OVERSHADOWS THE GARDEN AND IS THE MOST PROMINENT FEATURE IN ITS SETTING. THE PHOTOGRAPH WAS MADE FROM A POINT ALONG THE OLD AQUEDUCT NEAR PAINEIRAS.

of this fountain is constructed of large boulders partially overgrown by water-loving plants, altogether making a rare and very pleasing picture. The group of young men standing on the far side of the pool emphasize the great height of the palms bordering the central avenue that extends westward to the garden limits in this direction. At this point is located a small Greek temple, seen in the photograph, dedicated to the Goddess of Palms—*Dea Palmaris*—a delightful conclusion to a scene unrivaled for variety and grandeur. No description of Rio de Janeiro is deemed complete without some reference to this remarkable avenue and its majestic trees—it is the Garden's "feature" exhibit.

Leandro Avenue extends northeastward from the octagonal monument that shelters a bust of Frei Leandro, a Carmelite Priest and naturalist, who was the first director of the garden. This monument rests on a mound by the shore of Leandro Lake, which contains many interesting species of water plants. On the mound itself we noted a vigorous specimen of ***Fourcroya gigantea*** on the left, below which is a species of Azalea; on the right of the stone steps leading up to the monument is a bunch of Vetiver (***Andropogon squarrosus***), an Old World grass valued for its fragrant roots that yield a delightful perfume.

Along this avenue are many interesting trees and shrubs. It crosses the Avenue of Palms at the Allegoric Fountain, and beyond this point is bordered by *Michelia champaca*, a handsome tree related to our magnolias, from tropical India and the Malayan Islands. Its attractive yellow flowers are very fragrant as is its wood, which is useful in construction work of many kinds.

The fountain in the foreground is from Gromort, "Gardins d'Espagne." Corcovado is plainly visible to the north beyond the garden limits, where it terminates a lovely vista.

The Botanical Garden at Rio de Janeiro, with its shaded avenues and well-filled area, is unrivaled in beauty of plan. The landscape architect has made it a delightful place for the public seeking restful enjoyment, while the directorate have acquired equipment that will please the botanist, introducing him to many strange and fascinating members of the plant world. Close inspection of the collections will reveal much to the interested observer, inspiring a greater love for plants and a better understanding and appreciation of their values to human interests.

The garden has attained the ideal of an effective institution of learning, where the plants of the world are brought together in harmonious design for serious contemplation and study. The student may here experience all the delights of original research and discovery, in the science of botany.

# IF THE BLIND LEAD THE BLIND SHALL . . . ?

## OR REFLECTIONS ON RECENT REVIEWS OF "ANIMAL TREASURE"

By ARTHUR LOVERIDGE
MUSEUM OF COMPARATIVE ZOOLOGY, CAMBRIDGE, MASS.

WHAT is the purpose of a book review? The practice of book reviewing would appear to have arisen in response to the demands of book-lovers subjected to such a spate of literature that they feel the need for guidance as to what is worth-while reading.

If this much is conceded then the reviewer is a person placed in a position of trust; especially would this appear to be the case when his scientific standing or technical knowledge is calculated to lend special importance to his opinions.

These reflections have arisen as a result of reading the reviews of "Animal Treasure" written by Messrs. Clifford H. Pope and Hans C. Adamson in the *New York Herald Tribune Books* (September 12, 1937, p. 3) and the *New York Times Book Review* (October 3, 1937, p. 3), respectively.

"Animal Treasure" is an account by Ivan T. Sanderson of an expedition which he made to the Cameroons to collect zoological material for various individuals and institutions who contributed to the cost. Among these was the British Museum, which subscribed $250, and the Percy Sladen Trust, which was the chief sponsor.

As "The Book of the Month" selection for September, "Animal Treasure" is printed with the artistic skill which one associates with the Viking Press, nor can we wholly blame the publishers for being deceived if such gentlemen as Pope and Adamson give the work high praise. Moreover, Mr. Sanderson gained a tripos at Cambridge, England, which might well be considered evidence of ability to give an accurate account of his observations in West Africa. The present remarks are not in the nature of a review of the book, for that I have done already[1]; they are a challenge to Messrs. Adamson and Pope to justify their reviews.

Mr. Adamson writes: "From cover to cover the book is interesting to the lay-reader aside from such additional value as it may have to the advancement of natural history science" and "the backbone of 'Animal Treasure' is fashioned out of the competent and careful investigations of three men."

Mr. Pope says: "Every naturalist and scientist will devour this book and no lover of nature or adventure should let it escape."

Now to me "Animal Treasure" appeared to be just another attempt at the commercial exploitation of science, and was to so large an extent a compound of misstatement, misinterpretation, exaggeration, sensationalism and emotionalism that one was at a loss to know on what to place reliance.

It is obvious that these diametrically opposing views of the book can not be harmonized, so I should like to ask Messrs. Adamson and Pope whether they really meant to endorse the numerous misstatements made by Sanderson, samples of which are given below and numbered serially for their convenience when replying.

Not the least of Sanderson's mistakes is in referring to himself as a scientist

[1] *Atlantic Monthly*, "Bookshelf," October, 1937; *Copeia*, "Reviews," November, 1937.

(p. 14), the bare statement being greatly amplified by some of his admiring reviewers. While it is true that the word "scientist" has been so misused of late that it has become an almost meaningless epithet, in its biological association surely it connotes one addicted to careful, unprejudiced observation, who records his observations without exaggeration, cautious in deduction and with at least some foundation of fact for his theorizing—in other words, a scientist is a searcher after truth. I propose to show that in none of these characteristics does Sanderson conform to the requirements.

1. Adamson, credulous co-author of "The Empire of the Snakes," refers with uncritical approval to Sanderson's description of an incident with a "spitting" cobra. " . . . some of the brown liquid fell on my flannel trousers. I did not notice it at the time but a few days later there were tiny holes where it had been, as if acid had been spilt on the material. Imagine the effect of such a substance if it finds its mark—the eyes" (p. 29).

Now observe that the "scientist" (a) never saw the venom fall upon his trousers, (b) but describes its color, (c) and finding holes in his pants some days later, (d) *assumes* the occurrence, (e) then on the basis of his assumption proceeds to *imagine* its effect on the eyes. (f) He publishes this without ever attempting to check his theories with the known findings of the ascertained action of this venom based on careful experiments by well-known physiologists.

On several occasions I have had the venom of "spitting" cobras alight on my bare arms and neck as well as on my shirt; it invariably crystallized rapidly into spicules of a *pale yellow* or clear amber color. I have spoken to at least six Europeans who have received the venom full in their eyes at short range: in only one case—after the instantaneous but transitory painful reaction had passed—was the sight in the least permanently affected.

2. Pope, author of "Snakes Alive," the best popular account of snakes yet published, avoids all mention of Sanderson's encounters with snakes, including the story of a native who was bitten by a snake that he had brought in. The victim remained unconcerned and calm, not so the excitable Sanderson. Despite the court messenger's assurance that the man would not die—and when natives agree that any creature is harmless one may be sure that it is—without pausing to ascertain by opening the snake's mouth whether it was poisonous or not, we are told: "I then cut a very considerable piece of his thumb off and rubbed raw permanganate of potash crystals into the wound" (p. 323). With a wealth of dramatic detail the tale continues to its climax.

Now this species of snake, longitudinally striped red and black, is so distinctively colored and so common that "even the native women recognize it as harmless," so Dr. G. W. Harley, medical missionary of Liberia, informs me. It is one of the first species which a herpetologist would pick out and name on sight when identifying a collection of West Coast reptiles. As the snake was preserved it may be fairly assumed that Sanderson knew its name when writing; why, then, did he withhold it from the reader? Was it because that as *Bothrophthalmus lineatus*, a perfectly harmless colubrine, this unimaginative fact might mar a good story?

On reading this suggestion, Sanderson wrote me (September 9, 1937) that he omitted the name because "there was some doubt as to whether the 'red-and-black-snake' was actually *Bothriophthalmus lineatus* [*sic*], which required further investigation." But Mr. H. W. Parker, curator of reptiles at the British Museum, to whom Sanderson is indebted for the identification of all his reptiles and amphibians, recalls no such doubts (October 4, 1937)! Under any circumstances its identification as a harmless

species must have been known to the author when writing.

3. Adamson seems thrilled with Sanderson's "set-to with a giant hairy spider which came within a millimeter of sinking its deadly fangs into his face." But let Sanderson tell the story himself; he writes that it was "about the size of my two fists held together" and it took "six-foot leaps . . . at anybody who approached it." "As it did so, I felt the most terrifying coldness come over me. In a flash I let out a scream of pure terror and fell sideways into the ditch. Luckily I moved to the left, for the giant spider just brushed by my right ear so that I felt its loathsome furry coldness as it shot through the air to land beyond in the ditch" (p. 226). One can not but wonder at the acute perception of changes in temperature which is involved in the last sentence.

He continues: "When this terrible creature had been drowned, I steeled myself for an examination of her. As soon as I had satisfied myself that she was dead beyond a shadow of doubt, I spread her out in the enamel dish that we used for dissections. . . . The great legs, fully extended in all directions, covered the bottom of the dish exactly, from front to back and side to side. The dish measured twelve inches by eight inches" (p. 227). These statements intrigued me, for, when curator of the Natural History Museum in Nairobi, I had measured a mygale in the collection whose outstretched limbs were eight inches across. Yet when the legs were contracted around the body, as in death, the creature was kept in a specimen jar whose diameter was only two and three-quarter inches across, *i.e.*, much smaller than a single fist.

I therefore requested Mr. R. J. Whittick, who is in charge of the British Museum collection of arachnids, to furnish me with the dimensions of Sanderson's largest spider. He replied (October 4, 1937) that: "The length and breadth of the area covered by the outstretched legs is approximately $19 \times 16\frac{1}{2}$ cm." So that we find the spider which measured $12 \times 8$ inches in Africa is apparently only $7\frac{1}{2} \times 6\frac{1}{2}$ inches in London, and is substantially about the same size as the specimen in the Nairobi Museum.

4. Typical of Sanderson's reactions to the unfamiliar is his absurd description of a mantis. "The mantis is a truly terrifying creature, apparently always willing to engage in a battle, even with man" (p. 45). Compare this with Dr. David Sharpe's description in "The Cambridge Natural History": "The Mantidae, as a rule, have a quiet unobtrusive mien, and were it not for their formidable front legs would look the picture of innocence. This appearance of innocence and quietness must have struck all who have seen these Insects alive" (5, pp. 248–249). This conforms to my own impression of these delightful little creatures, of which I usually kept several on the window screens, where they performed yeoman service in keeping down insect intruders. Sanderson says, however, "I dislike these vampires" (p. 46).

5. In regard to the eating of the male mantis by the female, he continues: "In fact the love-life of the mantis consists of this gruesome performance alone, for without it the male is unable to impregnate the female. Only in its writhing death-agonies can it conclude the act of copulation" (p. 45).

This is simply untrue; though the basic fact that a female mantis will on occasion devour her mate, as do the females of certain species of spiders, has long been known to entomologists, and may be read in "The Cambridge Natural History" (5, p. 249).

6. Of a shrew (*Potamogale velox*) we read: "There is a fantastic animal, a veritable living fossil, that inhabits the mountain streams of West Africa . . . nobody has been able to add to or sub-

tract from the original descriptions by du Chaillu. This has led to the *Potamogale's* becoming almost a zoological myth" (p. 228).

Pope, accepting this, refers to the animal as "exceedingly rare," though the American Museum of Natural History, with which he was connected for so many years, received fifty-one examples from the Lang-Chapin expedition. This material was extensively discussed in the *Museum Bulletin* by the late Dr. J. A. Allen. The Museum of Comparative Zoology has five Cameroon specimens; doubtless other museums are also well supplied. Even if not, with such abundant material in the American Museum how can the creature be said to be almost mythical? This is but one of several creatures whose rarity is exaggerated by Sanderson, whether through ignorance of the literature or with the object of magnifying the achievements of his party, one can not say.

7. It is in his attempts at biological speculations that Sanderson blunders most. As an example, let me cite the following: "We captured six diurnal animals in Africa that belonged to groups all the other members of which are exclusively nocturnal. All six animals—a snake (*Gastropyxis senaragdina*) [*sic*], a squirrel (*Funisciurus poensis*), a monkey (*Cercopithecus pogonias*), a rat (*Oenomys hypoxanthus*), a flying squirrel (*Anomalurus beecrofti*), and, finally, a lemur (*Galago demidovii*)—were bright green above and yellow beneath, whereas their near-related and nocturnal species were all of other colors" (p. 167).

One hardly knows what to say about such utter nonsense. The snake, squirrel and monkey all belong to groups which are strictly *diurnal,* the rat, scaly-tail and galago to groups which are *nocturnal,* and I am not disposed to accept Sanderson's statement that these latter species are diurnal, with the possible exception of the rat.

Through the courtesy of my colleague, Dr. G. M. Allen, I have been able to examine Cameroon material of all these mammals. Not one of them is bright green above; the nearest approach is the grizzled olivaceous squirrel, and this is the only one of the five with any yellow below, except for a slight strawish stain on the chin of the monkey, whose breast is white. Thus we find that the snake is the only creature corresponding to Sanderson's description of "bright green above and yellow beneath," the squirrel, by courtesy, a second. It is well known to mammalogists that the pelage of mammals undergo no radical changes on preservation beyond a slight dulling and fading with the passage of time. In view of the above, his theory about bright green and yellow mammals need not be discussed.

The explanation would appear to be that he uses scientific names without really knowing the creatures to which they refer; this is obvious in several instances, even with such well-known creatures as the water mongoose (*Atilax paludinosus*) which, says Sanderson, "is elegantly cross-striped" (p. 34).

8. Perhaps one of the most amazing claims in this extraordinary book is that relating to a scincoid lizard (*Lygosoma fernandi*), and here we must give Pope credit for the mild statement that it "will strain the credence of many a reptile man." Sanderson and his companions were returning to camp just as day was waning "when out of the stillness of the evening came that dreadful crescendo whistle." (The adjective may be attributed to the state of nervous tension in which Sanderson appears to have passed his days and nights.) Two of the natives said that it had come from "the head of a long narrow valley ascending the mountain to our right." Sanderson and his companion thought that they "were exaggerating considerably in saying that it had originated so far away." However, they set off, and after what was

apparently quite a journey, "the valley narrowed to a ravine, the sound became gradually more piercing and as we still ascended, its volume increased to an extent that I had never believed possible; *in fact, I have never met a louder sound caused by an animal.*[2] The whole air literally reverberated each time that it swelled forth. It might have been a really powerful fog-horn" (p. 201).

The sound ceased; so the party sat down in the fast-gathering dusk, then "From beneath the very next clump of grass to that on which I was sitting that awful whistle began; but as I whisked round, it was cut short before reaching the peak of its crescendo." Surrounding the clump, they found nothing but a steeply descending burrow, in a branch of which they killed a skink. Sanderson continues: "So this was the phantom. No wonder nobody had ever suspected its true origin. Lizards are a silent group except for the geckos, and none other has ever been recorded that makes a noise like a fog-horn. Many have been disturbed, annoyed, almost driven mad by this noise in Africa; they will know what to hunt now" (p. 202).

When Sanderson returned with this story to the British Museum, he was told that skinks were considered a voiceless group and counseled to dissect some specimens to ascertain if there was any physiological basis for the idea before publishing so startling a claim. Instead, the "scientist" approved by Pope and Adamson writes: "Although I have been back now from this expedition for nearly four years, the pressure of work entailed in dissecting rather more important animals has not yet given me time to examine this lizard, and find out how it makes its eerie noise" (p. 203). He then figures the creature under the caption "Whistling Skink (*Lygosoma fernandi*)."

[2] Italics mine to emphasize the powers attributed to a lizard measuring at most eight inches from snout to base of tail.—A.L.

On reading Sanderson's account, and after making due allowance for the writings of an imaginative "zoologist," I was struck by the resemblance of his description to the vibrant shrilling sound made at dusk by sturdy crickets (*Brachytryptes membranaceus*), as they sit in the entrance of their burrows in rather dry grasslands as I have described elsewhere (*Proc. Zool. Soc. London*, 1923, p. 1036). I was unaware, however, whether this species extended its range to the Cameroons, so wrote to the well-known orthopterist, Mr. A. G. Rehn, who recently returned from the Cameroons and was then in Arizona. It so happened that before I received his reply, Dr. G. W. Harley arrived at the museum with zoological material from Liberia. I started to tell him about Sanderson's skink, the sound attributed to it, and the cricket, when he interrupted me to say that he knew both skink and cricket well and that I would find examples of both in his collections. Furthermore, he was familiar with the deafening shrilling of the cricket, and considered my designation of the cricket as the producer correct. He thinks, however, that Sanderson is confusing two sounds, the whistle being the work of secret society men in the forest, so the natives are reticent as to its origin. A few days later I got Rehn's letter saying that he heard *membranaceus* at very many points in his journey across the continent from Kenya to Cameroon and that it was the commoner of the two species occurring in the Cameroons. The fact that the three *fernandi*, which I have personally captured, were silent is no evidence, but I am sufficiently convinced that my explanation, and not Sanderson's, is the correct one despite his claim that the dying lizard emitted a faint replica of the noise while in his hand. If a cricket had given a chirp nearby he might easily have mistaken it.

9. Both Adamson and Pope are duly impressed with Sanderson's "nasty en-

counter with baboons." The account is chiefly amusing as a description of the reactions of an imaginative young man in a strange environment. He was admittedly too terrified to fire until after he had run away. Who has ever heard of drills attacking a man? Were a baboon which had strayed from its true environment into the middle of Fifth Avenue to give an account of the alarming honking and apparent intentions of the automobiles around it, such an account would be about as trustworthy as that of the agitated Sanderson's first meeting with mandrills in the primeval forest.

10. It is not merely under the storm and stress of his emotions that this "scientist" is unreliable; it would appear as if he could not copy from other authors without adding fantastic flourishes from his fertile imagination. Writing of the toad *Nectophryne batesii,* he says that Mr. G. L. Bates "found a male sitting on a brood of eggs laid in a little cup made by neatly sewing together two pendent leaves" (p. 94). It never occurred to him to explain the not unimportant point as to how a toad does sewing.

Compare his description with what Dr. G. A. Boulenger actually wrote: "Mr. Bates has sent me a specimen, a female *N. batesii* with empty oviducts, found by him at Bitye, Aug. 12, 1909, under the trough or hollow of a plantain-leaf petiole, crouched in the midst of a mass of eggs." (*Ann. Mag. Nat. Hist.* (8), 12, p. 71.) In other words a female, not male, was found ensconced upon her eggs beneath the base of a banana leaf apparently lying on the ground.

11. This is the author of whom Pope writes: "He also convinces one that the truth about wild animals is quite as thrilling as the most carefully constructed fabrication"—the same Sanderson who states that he "even saw a reason for the endless repetition of false statements about the majority of animals" (p. 13), who understands "why one expensive expedition after another was returning, having done little more than spend its money" (p. 13).

That truth may prevail, Sanderson explains the primary importance of selecting expedition personnel with due care, for of the applicants about "half will probably be zoologists. These must be eradicated without delay because there is nobody with less imagination or more hide-bound notions of procedure than the average young zoologist" (p. 15). From this one may conclude that the author does not consider himself an average young zoologist: a distinct matter for thankfulness, for if Cambridge were turning out more of the Sanderson type zoology would become a byword.

But let him continue to state his opinions. He writes: "Upon this subject I hold views diametrically opposed to everybody else's, the medical world and people who have lived in the tropics not excluded." "For the tropics and hard work weed out all the athletes, sportsmen . . . select all those who are at least used to and at ease in smoky bars, airless cabarets, and crowded subway trains. . . . Last come questions of compatibility of temperament and similarity of tastes" (p. 15).

So he chose an old Parisian acquaintance named George. "George fulfilled all the conditions." One not unnaturally looks forward to reading of the excellent health enjoyed by so hand-picked a couple; nothing of the kind, however, for we constantly come across such statements as the following: "When George got persistent low fever and was told that he was dying of consumption I rushed him down to the coast meanwhile wiring frantically for someone else to be sent out to me to take his place" (p. 16). "George had . . . returned to the base for a rest because persistent low fever

made him feel, as he put it, like a dish of scrambled eggs. I was shivering myself . . ." (p. 118) or "I was lying under my mosquito net shivering and aching with an attack of malaria" (p. 36). Sanderson should forgive his readers if they are not very impressed with his revolutionary theory of the type of men desirable for the tropics.

12. "Since sundown (and our frugal meal) we had been busily employed measuring, examining, and cataloguing the day's catches. The incessant beating of the rain upon the taut canvas above was only fitfully dispelled by blasts of stentorian jazz produced by the gramophone" (p. 90). Judging from similar frequent allusions to the gramophone it would appear that the "scientists" could only work when it was blaring. Perhaps in this we find an explanation of erroneous measurements and misstatements, for Sanderson assures us that he "kept a very detailed diary in Africa" (p. 17).

"A youth donned the juju mask and executed a dance before me with a young girl. My eyes nearly popped out of my head as it proceeded, for . . . it was the *beguine*, . . . well known to me from happy evenings spent in the supersophisticated cabarets of Paris" (p. 25). "There happens to be a group of persons of most undoubted African descent now resident in America who call themselves—or are called by their manager—the Washboard Rhythm Kings, and they make music. Their records were a particular passion with us, one of them in fact being the expedition's national anthem and always employed as an opening number" (p. 233).

13. Pope actually refers with approval to Sanderson's imaginative descriptions of the forest and its fauna, such as: "One of the first laws revealed to us was the unsuspected fact that the life of the jungle is like that of the ocean floor. This has never been observed or remarked upon before. Everything drifts slowly hither and thither as if wafted forward by currents and cross-currents. To stand still is to arouse suspicion, just as a diver, who can actually handle fish and other sea creatures provided he drifts with them across the bed of the sea, becomes an object to be feared and shunned as soon as he remains immobile and anchored. When hunting, we adopted two entirely different methods. George concealed himself at some vantage point and waited for the waves of forest life to drift by him; I drifted and eddied with the animals themselves. Doing this, I learnt many things and so did he. The speed at which I drifted, I found, must vary with the weather. Bright fine days brought life almost to a standstill. In a hurricane I had to run to keep pace with things" (p. 75).

To the reader it is interesting to trace the continuity of the author's mental processes from the days when "Somehow the ideas of sunlight, beasts, and palm trees got all mixed up in my childish fancies" (p. 12).

14. Sanderson apparently assumes that the memories of his readers are as short as his own. As Discoverer of a New Idea (p. 14), he says: "Scientific methods of collecting animals were out of date" (p. 13). "We went not to shoot, nor merely to collect, but actually to study the animals in life and record their differences of appearance, behaviour, and habits as they really are in nature" (p. 17).

How soon these ideals were forgotten can be seen from cover to cover of the book. "Gong-gong's call to arms was the signal for a wild scramble for loaded shotguns, always kept to hand" (p. 23). "For a whole year (*sic*) we waged ceaseless warfare against the hawks, and on only one occasion did we obtain the same species of bird twice" (p. 24). "Their only use to us was as targets for shooting practice, and fine sport they provided

for this" (p. 24). Why this ruthless destruction of wild life, for not a single bird was preserved?

Another example of nature study will be found in the account of the killing of a python which, but for their fears, Sanderson and his boy Dele might easily have captured alive. This even if we accept Sanderson's measurement of "ten feet six and a half inches." Note the confidence in scientific accuracy inspired by the last half inch. The author relates how he and his companion chopped at the hapless reptile with "battle-axe" and "trapper's friend." Sanderson continues: "After some time of feverish activity in which I cooperated heartily, he seized what appeared to be a bloody clot of earth and began to pull. . . . When I say six and a half inches, I am not strictly accurate, as the head was a mere meaty slush, hacked to pieces" (p. 64). Probably most museum men will prefer the old methods after all.

15. One of his reviewers speaks of Sanderson's evident love of animals. This is scarcely borne out by the book, where we actually read of his firing random shots in sheer spite for the fright that a company of mandrills had given him. It is true that he ran away to what he considered a safe distance first (see p. 56) as was to be expected "Being above all a coward" (p. 25). Again of a hawk we read: "I decided to take a chance shot at it though I thought it almost certainly out of range" (p. 25). Elsewhere we learn of an adder "drowned in a bottle of alcohol" (p. 30), and "all the frogs were eventually caught and drowned in the all-absorbing alcohol" (p. 37).

Now a humane collector would have chloroformed his victims. You have only to take a little alcohol of the strength commonly employed in the preservation of specimens, and sprinkle it on the eyes or on the mucous membrane of the lips, to gain an idea of the sufferings inflicted on creatures as they struggle in, and gulp down, the biting fluid as it "burns" into their vitals.

16. While no intelligent inquirer would look in Parisian cabarets for supporters of foreign missions, one has the right to expect a balanced judgment from even a cabaret-trained zoologist if he claims to be a scientist. Though the African continent comprises eleven million square miles and Sanderson has had less than eleven months experience of a very small area, having rejected the claims of Christ for himself, feels qualified to agree with a chief that Christianity is "the bane of present-day Africa" (p. 317). And of another chief we are told that he "soon observed . . . that I had almost as virulent a dislike of Christians as he had" (p. 297). Elsewhere he refers to a native who had "been subjected to the indignity and stifling stupor of a mission school" (p. 281). Prejudice implies prejudging and it is this quality in Sanderson that vitiates his views on mantis, mission and spider alike.

If Adamson approves Sanderson's book in these matters, it is in sharp conflict with the opinions of several of his colleagues who know Africa. Two of them—Professor Gregory and Dr. Raven—in their delightful book "In Quest of Gorillas" (1937), again and again refer with warm approval to the work of the many mission stations which they visited in their trans-African journey which ended in the Cameroons. Indeed, Raven, when he contracted sleeping sickness, had good cause to be grateful for the care and ministrations of a Cameroon missionary.

Space forbids my saying all I should like to on this matter. I think of the leper camps I have seen in Tanganyika, where missionaries labor year in and year out, and then I think of Sanderson . . . I think of Paulo, tent boy on my 1934 trip, honest and conscientious to the last degree, his faith so integral a part of his being that they could not logically be

separated. I do not deny that I have known mission boys who have betrayed the trust placed in them, my tent boy in 1930 certainly exploited his scanty mission training, but then there are zoologists who exploit science, though they have had infinitely greater educational advantages than the native.

17. Sanderson, "who wears his great scientific learning so naturally," as one of his reviewers (Dorothy Canfield) says, tells us that he chose the Cameroons "because it had the worst climate and medical reputation in the world" (p. 14) and for this reason might have been neglected by timid zoologists. Supposedly we are to admire his intrepidity, but for the Europeans who, by developing the country and opening it up, made his visit possible, he has nothing but scorn. Yet they live in "the worst climate" year in, year out.

His book opens and closes with sarcastic references to them and to "unspoiled Africa as it was before Europeans began crawling about it" (p. 11) —a statement which is incidentally quite incorrect. The last page but one embodies his reflections on his fellows in the form of a simile to the "dread weaver birds." He writes: "These busy active birds in their bright-orange ruffs with their drab, dingy women-folk seemed to me to be symbols. The beautiful verdant trees were, like Africa, stripped and peeled of their green glory by the activities of beastly busy creatures relying on their numbers and building their ugly nests all over the place. Every nest like every other, just like the drab houses and grim workshops of the dull Europeans who have colonized Africa—as they call it—in order the better to raise their unwanted progeny" (p. 324).

18. Adamson says, "If 'Animal Treasure,' fruit of an expedition conducted by Sanderson at the age of 25, is any criterion as to what he will accomplish in the future, then natural history science and the world of books owe Edinburgh a vote of thanks for having a climate that is cold and damp."

It is on account of the future that I have written as I have done. Sanderson has caused incalculable injury to natural history by disseminating false information, which is, and will be, quoted far and wide. He is even now in New York, engaged in writing a book on Haiti, a country from which he returned recently "with a broken nose and two dragons," we are told.

19. In fairness to Sanderson, however, I must reiterate that the foregoing remarks are not in the nature of a review of his book. Elsewhere I have given him credit for his gift of writing and paid tribute to his artistic talent. He is not a scientist, however, and to prove this I have quoted a few of his grossest errors; there are dozens of others to which no reference has been made.

That there is need and opportunity for able writers to interpret scientific truths in readable guise for the general public is self-evident. It should not be necessary, however, to play fast and loose with truth, nor garble the facts in the process.

20. We all make mistakes, and I think that if Messrs. Adamson and Pope are frank they will agree that they have no experience of Africa or its creatures. That being the case they should never have attempted to review such a book. They are not alone in accepting it as authentic: from coast to coast in these United States numerous reviewers have heralded "Animal Treasure" as a worthwhile contribution to African zoology. I have attempted to show that the reverse is the case.

# WHAT IS A PATENT OR PROPRIETARY MEDICINE?

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THE Constitution of the United States, in Article I, Section VIII, enumerates among the powers of Congress the following: "The Congress shall have power to promote the progress of science and useful arts by securing for limited time to authors and inventors the exclusive rights to their respective writings and discoveries."

Under this section of the Constitution the Congress has passed our patent and trade-mark laws. An inventor of a new and useful thing is given the right to make and sell it for a period of seventeen years. A patent is essentially a contract between the government, representing the public, and the inventor. In return for the disclosure of his invention, the government protects the inventor by giving him a monopoly on the making and selling of his invention for a term of seventeen years. The monopoly granted is not the right to make the article discovered, because the inventor possesses that right anyway. The monopoly consists in the right to exclude others from making, using or selling any embodiment of the patented invention during the life of the patent.

Here we have laid down by the Congress of the United States, acting under the Constitution, a definite policy with respect to inventions of new and useful things.

Contrary to the general assumption that the discoverer of a new and useful thing is entitled to exclusive and perpetual rights therein, the policy of the United States government and of all governments is based upon the assumption that a new discovery belongs to the people, but as a reward for the disclosure of the discovery, the inventor can exclude, by means of letters patent, acquired in a lawful manner, any other persons from enjoying the fruits of his discovery for a limited period.

It is expected that at the end of seventeen years the inventor shall no longer enjoy the monopoly under the patent law, although careful and judicious marketing policies will give the inventor a leading advantage over competitors who may decide to avail themselves of the use of any product on which the patent has expired.

In the field of drugs and medicines, the term "patent" has come to have an added significance. Not often does it refer to a medicine or drug on which a patent has been issued. There are, of course, newly developed chemicals or processes for the manufacture of chemicals on which patents can be secured. However, there is no such thing to-day as a "patented" medicine in the sense that the formula for preparing a mixture of drugs has become the basis for issuance of letters patent. The U. S. Patent Office has not been granting patents on mixtures of drugs in recent years, although such was the case in its earlier history.

In this connection it is interesting to examine the dictionary definition of the word "patent." Its meaning is given as follows: "Lying open; open; public; manifest to all; unconcealed; obvious; conspicuous; open to perusal of all, as letters patent; appropriated by letters patent; secured by law as an exclusive privilege; restrained from general use; patented; an official document—letters patent—conferring or granting a privilege; a patent of nobility; a patent conferring right to engage in a particular

trade usually to the exclusion of others; a letter of indulgence; a pardon."

Any one having to deal with laws enforcing regulations with respect to drugs and medicines would be intrigued by the first definition given. A patent medicine, so-called, is anything but a product of which the composition is revealed or which has a formula "open to perusal of all." Common parlance has given the word "patent" with respect to medicines a meaning which is the exact opposite of its dictionary definition, for patent medicines are generally considered secret formula products rather than open formula products.

The trade-mark laws of the United States have been employed in a very adroit manner to perpetuate the monopoly on patented products. If the individual who registers a trade-mark for a patented product is careful enough to apply his trade-mark in such a manner that it will indicate the brand of the patented product rather than the patented product itself, he can acquire unlimited exclusive rights to the brand name and by clever advertising he can continue to enjoy a virtual monopoly on a given product even after his patent rights have expired. Let me illustrate: The term "aspirin" was made synonymous with acetylsalicylic acid from the beginning of the marketing of that product in the United States. A patent was obtained on acetylsalicylic acid, but the manufacturer popularized the product under the name of "aspirin," and "aspirin" became the accepted name rather than the brand name for acetylsalicylic acid manufactured by the holder of the patent. Accordingly, when the patent expired, the term "aspirin" had acquired a place in the language of commerce and in the language of medicine. Exclusive right to the word "aspirin" could not be vested in the originator of the product after the patent had expired, because he had not taken the trouble to preserve the word "aspirin" as his brand name of acetylsalicylic acid.

The introducer of phenobarbital, on the other hand, was very careful to popularize the name "luminal" as the name of his brand of phenobarbital, and when the patent on this chemical expired the trade-mark "luminal" remained in effect and was renewable and is renewable at twenty-year intervals so that other manufacturers of phenobarbital may not use the trade-mark "luminal."

It can readily be gathered from even this superficial discussion of the subject that it is possible by the use of coined trade names registered with the U. S. Patent Office as trade-marks to go a long way toward perpetuating a monopoly on a given drug or chemical. By means of advertising and propaganda, the brand name of the product is made familiar to consumers over a period of seventeen years, and it is then very difficult for others who endeavor to manufacture the product at the expiration of the patent to convince consumers that their product is not an inferior substitute. However, there is greater opportunity to-day through advertising to break down the monopoly granted by way of trade-marks, and there would be even greater opportunity along this line were it not for the tacit understanding among the better class of manufacturers of drug products not to appropriate one another's patented products upon expiration of the patent.

Practically every pharmacy law in the United States makes a distinction in the regulations of the sale of drugs and medicines and the manufacture and sale of so-called patent and proprietary medicines. The regulations with respect to the sale of drugs and medicines are stringent. The regulations with respect to the production and sale of so-called patent or proprietary medicines are very

loose. Legislatures enacting pharmacy laws for the first time, some seventy or more years ago, were importuned to restrict the sale of drugs and medicines to registered pharmacists or persons working under the supervision of registered pharmacists. The patent medicine industry was sufficiently well organized, even in those days, to have inserted in all these laws a provision completely exempting patent or proprietary medicines from the provisions of such laws. The terms "drug" and "medicine" are generally defined in these laws along lines of the definition in the Food and Drugs Act. However, there is, in general, no definition given for patent or proprietary medicines.

When a definition is given, it is usually so worded as to include anything worth including as far as the patent medicine manufacturer is concerned and to exclude anything which would burden such manufacturer with any restrictions or responsibilities.

A definition for patent or proprietary medicine which has become a classic from the legal standpoint because it was handed down in an early court case involving an alleged violation of a state pharmacy law is that given by the Supreme Court of the State of Minnesota in the Donaldson case. It reads as follows:

> It is a matter of common knowledge that what are called "patent" or "proprietary" medicines are prepared for immediate use by the public, put up in packages or bottles, labeled with the name and accompanied by wrappers containing directions for their use, and the conditions for which they are specifics. In this condition they are distributed over the country in large quantities and sold to consumers in original packages, just as they are purchased by the dealer, without any other or further preparation or compounding.

The American Medical Association through its Council on Pharmacy and Chemistry has adopted the following definition:

> The term "proprietary article" shall mean any chemical, drug or similar preparation used in the treatment of disease, if such article is protected against free competition, as to name, product, composition or process of manufacture by secrecy, patent, copyright, or in any other manner.

The Commission on Proprietary Medicines of the American Pharmaceutical Association proposed the following definition:

> In its widest sense, a proprietary medicine is any drug, chemical or preparation, whether simple or compound, intended or recommended for the cure, treatment or prevention of disease, either of man or of lower animals, the exclusive right to the manufacture of which is assumed or claimed by some particular firm or individual, or which is protected against free competition as to name, character of product, composition or process of manufacture by secrecy, patent, copyright, trade-mark, or in any other manner.

This definition probably states the status quo correctly, but if it were accepted as a legal definition the field of "proprietary medicines" would be greatly enlarged and that of "drugs and medicines" greatly restricted.

It is, of course, manifest to any one who has studied the situation that most of the so-called proprietary and patent medicines are mixtures of well-known drugs devised to meet some condition which they are claimed to cure or relieve. The tendency to develop private formulas has been accentuated in recent years to the point where a pharmacist who is educated to prepare and compound medicines based on official drugs and preparations finds himself in a position of great bewilderment when he attempts to practice his profession in a prescription room labeled with new combinations of drugs offered under fanciful names and with prescriptions from physicians calling for all types of combinations of official and unofficial drugs prescribed under names assigned to them by manufacturers and registered as trade-marks.

In order to avoid duplication of names by the manufacturers themselves, the

American Drug Manufacturers' Association maintains a pharmaceutical trademark bureau with which the members of the association can register new names, and these are made available to other manufacturers so as to avoid costly litigation or wasting of time in searching trademark records when it is necessary to coin a new name. A mere glance at this register under two important headings—Digitalis and Ergot, for example—will indicate the "confusion of tongues" that prevails in the modern prescription department when an inventory is taken of these preparations and the difficulty met by the conscientious pharmacist who tries to keep in touch and up to date with this field.

The names for Digitalis preparations registered with the American Drug Manufacturers' Association follow: Digicar-dalis, Digicardium, Digidin, Digifol, Digifortis, Digiglusin, Digiloid, Digilutea Upsher Smith, Diginfuse, Digipit, Digipit No. 2, Digipura, Digiquin, Digirex, Digismith, Digitalex, Digitaligen, Digitalone, Digitan, Digitex, Digitol, Digitone, Digitora, Digitos.

The names for Ergot preparations registered with the American Drug Manufacturers' Association follow: Ergaloids, Ergo-Aloe, Ergoapiol, Ergoettes, Ergone, Ergonol, Ergophene, Ergophenol, Ergopit, Ergopit No. 2, Ergo-Quinine, Ergosekalo, Ergo-Stat, Ergot Aseptic, Ergotean; Ergot, Fluid Extract, "Formula of 1874"; Ergo-Thaelin, Ergothesin, Ergotole, Ergotora, Ergot Potent, Ergotrate, Ergozin, Ergo Zinc Comp., Ergyne, Erpiol.

Two recent advertisements of so-called ethical proprietaries tell a significant story in a very few words. Parke, Davis and Company are advertising Kapseals Ventriculin with Iron and Vitamin B. The formula is given as follows: Ventriculin—5 grains, this is the proprietary name for Stomach now official in the U. S. P. The next ingredient is Naferon—2 grains, this is Iron and Ammonium Citrate Neutral and then there is some Vitamin $B_1$ and Vitamin $B_2$. This mixture is ready made and put up in capsules, but in order to identify the capsules a yellow capsule is used with a black band around the center which makes this a Kapseal rather than a capsule. Not only by coining a name for the ingredients, which are common official drugs, but also in the manner of dispensing did Parke, Davis and Company appropriate to itself the exclusive right to this formula. A pharmacist putting up Dried Stomach and Iron and Ammonium Citrate Neutral with Vitamins supplied in some form in a plain gelatin capsule would be a substituter and guilty of a heinous offense. A general merchant selling Kapseals Ventriculin with Iron and Vitamin B would be wholly within his rights under the pharmacy laws, because undoubtedly Parke, Davis and Company would claim that this is a proprietary preparation. The reference here has been to a medicine which would be prescribed by physicians ordinarily, but which will soon become an article of commerce if it is found to be of any value in some special condition and the word is passed along from one patient to another. For the present, it will doubtless remain a prescription product, but the common patent medicines of to-day have been prescription products in the past.

E. R. Squibb and Sons have recently announced the marketing of Ammonium Mandelate under the name of Mandamon. The Squibb brand of Ammonium Mandelate is trade-marked under the name of Mandamon. Apparently it is not sufficient to specify "Squibb" in connection with Ammonium Mandelate. The physician is importuned to prescribe this product under the name of Mandamon, and hence the pharmacist who possesses a chemically pure Ammonium Mandelate in

his stock would be considered a substituter if he were to supply this upon a prescription calling for Mandamon.

If there is to be any control over the sale of drugs and medicines, a way must be found to extend that control over all medicines, regardless of the fact that they are classified as "patent or proprietary preparations" through the arbitrary use of these terms in our pharmacy laws or through a conversion of the meaning of these terms to suit the purposes of manufacturers.

A good illustration of the further abuse of privileges granted in connection with the sale of patent or proprietary preparations is the insidious development of taking common official drugs and medicines, changing their formulas slightly, giving them fanciful names and palming them off as new discoveries to be sold without the restrictions that govern the sale of drugs and medicines. A case in point is the Citrate of Magnesia situation with which many states are confronted to-day.

The Crescent Bottling Works of Newark, N. J., has been supplying general merchants with a product labeled "Duke's Magnesia Citro-Tartrate," which upon analysis was found to be a Solution of Citrate of Magnesia approximating the U. S. P. formula but somewhat deficient in Citrate of Magnesia according to the U. S. P. standard. Under the laws of New Jersey, Solution Citrate of Magnesia, being a drug and a medicine, can be sold only under the supervision of a registered pharmacist. By a slight alteration or adulteration of the U. S. P. product and giving it the name "Duke's Magnesia Citro-Tartrate," the attempt was made to classify this product as a patent or proprietary medicine which, under the laws of New Jersey, may be sold to any one without supervision. The facts in the case were brought before the Court of Chancery of the State of New Jersey because the Board of Pharmacy had taken the position that Duke's Magnesia Citro-Tartrate was a medicine and a drug and not a patent or proprietary medicine within the meaning of the pharmacy act, regardless of the name which had been appropriated by the manufacturer. In the district courts, merchants who had sold the product were penalized when the board demonstrated that the product sold was an adulterated Citrate of Magnesia preparation in a Citrate Magnesia bottle but with a fanciful name. The manufacturer, considering himself aggrieved because such procedure led to reduction of sales, went to the Court of Chancery for the purpose of enjoining the Board of Pharmacy from enforcing the pharmacy act in accordance with its interpretation. A temporary injunction was granted, but upon final hearing the vice chancellor hearing the case held that "the product in question was merely common Citrate of Magnesia, a recognized drug preparation, slightly adulterated and of slightly less potent character, and hence within the prohibitions of Section 2 of the pharmacy act." Accordingly, he vacated the preliminary injunction and dismissed the bill.

The manufacturer carried the matter to the Court of Errors and Appeals, which is the highest court in the state, and this court upon reviewing the evidence gave it as its unanimous opinion that "on the evidence, the above finding of fact is manifestly right." Accordingly, the decree was affirmed.

This indicates clearly that when the nature of the subterfuge practiced by manufacturers under the exemption clause of the pharmacy acts is presented to the courts in its true light, they are not fooled. It also indicates that the clause in most pharmacy acts which exempts so-called patent or proprietary preparations from their provisions is not iron-clad, but is in fact vulnerable if enforcement

agencies will take the trouble and pains to establish the facts.

In the writer's judgment entirely too much has been taken for granted in connection with this exemption clause. It does not seem logical that the courts of the United States are willing to give the patent medicine manufacturer the benefit of every doubt all the time. In most instances where court decisions have been rendered on this subject there has not been as much expert testimony and expert legal guidance in the presentation of the case on the part of those opposing the patent and proprietary medicine interests as there has been on the part of these interests.

An illustration which might be cited is in the field of proprietary disinfectants. In some states it is unlawful for any one to sell poisons except under the supervision of a pharmacist. Manufacturers of insecticides and disinfectants containing poisons have adopted the simple expedient of leaving off the label the word "Poison" in cases where their product is shipped into states requiring sales to be made under the supervision of pharmacists. A case in point is the product Klenol. First it was supplied in New Jersey with a poison label. When the company manufacturing this product became aware of the fact that the New Jersey law prohibits the sale of poisons except under the supervision of pharmacists, the product Klenol appeared without a poison label. It is the same product and the question arises, is it or is it not a poison?

Our food and drug laws and our pharmacy laws are very specific in their requirements with regard to the sale of drugs and medicines and with regard to the manufacture of drugs and medicines. As matters stand to-day, the public receives ample protection by law where such protection is least necessary. In the great field of so-called patent or proprietary medicines, almost anything goes and will continue to go until we correct the outworn classification of medicines into the present divisions of plain "drugs and medicines" with revealed formulas and "patent or proprietary medicines" with secret formulas. Such a classification is purely in the interest of manufacturers relying upon trade-marks and secrecy for the protection of their business interests and contrary to the public interest which demands revealed formulas in open competition for such types of self-medication as may be considered safe and harmless.

Some years ago the Committee on the Costs of Medical Care expressed itself on this question in the following words: "The manufacture and distribution of medicines, because of their intimate relation to the health and welfare of a community or nation, partake of the nature of public utilities. In view of the shifting of control from professional to financial hands, manifested by recent developments in the drug industry, the public interest may require 'regulation' of the industry, through the guarantee of a fair return to investors and the limitation of prices to be charged to consumers."

The first and most important effort in this direction should be the elimination of the arbitrary line of demarcation between drugs and medicines and patent or proprietary medicines. The terms "drug" and "medicine" encompass anything that might be conceivably prepared or distributed under the classification of patent or proprietary medicines. If we classify all remedial agents as drugs and medicines under our pharmacy and food and drug laws, the public will receive equal protection in connection with all types of remedial agents. As soon as we create a separate classification, such as patent or proprietary medicines, whether these terms be synonymous or whether they are given individual meanings, we are draw-

ing an arbitrary line for which there is no justification in fact.

Manufacturers of so-called patent or proprietary medicines have created for themselves special privileges under the laws of the several states, which constitutes the rankest kind of class legislation and which no legislator can justifiably approve when he is confronted with the facts.

We need not deny a manufacturer property rights in patents for chemicals or drugs acquired in a legitimate manner. We may even be justified in procuring by law exclusive rights for limited periods to manufacturers for new discoveries and combinations which are not patentable and which contribute to the general welfare and to the progress of medical science and the healing arts. If the government of the United States and other governments throughout the world consider it a fair and equitable policy to *limit* the *exclusive* rights of inventors to their respective discoveries, why should these same governments grant to those who appropriate the discoveries and the fruits of the labor of other such rights *in perpetuity?*

The legitimate drug industry exists as a subdivision of the medical profession. Its obligations to the people are fundamentally the same as the obligations of other professions which provide medical care. Its legitimate economic interests should be protected, but it is not entitled to a permanent monopoly on the scientific achievements of others nor even on its own scientific achievements. To argue otherwise is to argue in favor of suspension of progress in medical science. That an unfair monopoly exists to-day is apparent to any unbiased student of the situation. That this unfair monopoly hangs largely upon an outworn, outmoded and arbitrary classification of drugs in our pharmacy laws has not been fully recognized. The abolition of this outmoded and unfair classification is in the interest of the public health and welfare and should be brought promptly to the attention of every legislature in the United States with the proper supporting facts.

# "MIKES"—A BOTANICAL ENIGMA

By REGINALD D. FORBES

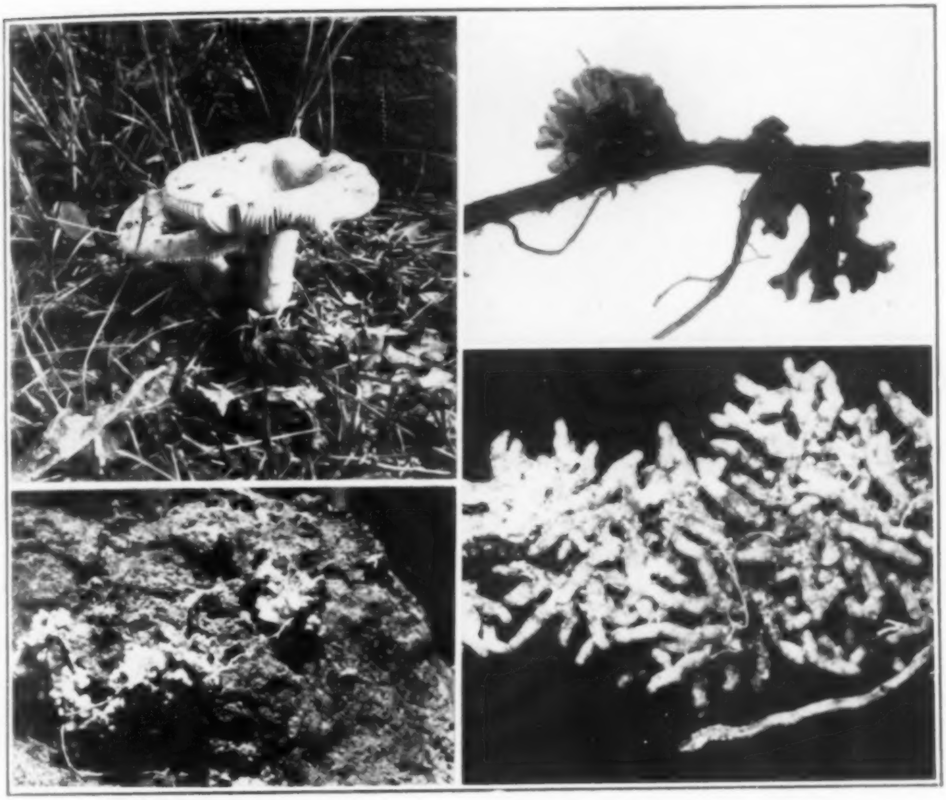
WHEN, seventy-five years ago, the eminent German botanist Frank peered through his microscope at some tiny club-shaped appendages he had found on the fine roots of a spruce tree, he started a controversy which has waged furiously in the scientific world ever since. Because his studies revealed that these appendages were composed of a mantle of extremely tenuous mycelia or vegetative strands of a soil-inhabiting fungus covering the smallest roots of the spruce, he called them mycorrhiza. The "myco" was Greek for fungus, and the "rhiza" was Greek for roots.

Years later the term mycorrhiza on the lips of American students of botany, many of whom possessed "little Latin and less Greek," assumed a distinctly Hibernian flavor, best interpreted in print as Mike O'Rhiza. To the modern student I believe they are known simply as "mikes." Like the impecunious wag who called banknotes above the denomination of $5.00 "Williams," because he was not familiar enough with them to call them "bills," I myself am content to call them mycor-rhiza.

The controversy, however, has not been about pronunciation. The question with respect to mycorrhiza which has split the botanical world is whether this odd combination of a lower with a higher plant is harmful or beneficial to the higher one. Does the mycorrhizal fungus, belonging to a lower order of plants incapable of manufacturing their own food from air and water, with the aid of light, and which ordinarily live on the tissues of plants which have that capacity, in this case also draw its nourishment from the tree? In other words, is this subterranean dweller a parasite, appropriating food intended for the green leaves, far above, of its unwilling host, or does it, as it were, pay for its board by assisting the tree to obtain moisture or plant food from the soil they inhabit in common? This sort of teamwork, known as mutual symbiosis, is not uncommon in nature and has its most familiar illustration in the plant world among the lichens. A lichen is not one plant, but a combination of two—a fungus and an alga. The fungus supplies a tough but translucent dwelling for the alga, which alone of the two has the power to utilize sunlight in the manufacture of enough food from the air to supply both plants.

A third possibility is that the mycorrhizal fungus plays Dr. Jekyll and Mr. Hyde to the higher plant, sometimes contributing a fair share to the combination, like a good mutual symbiont, and at others taking what it needs without giving much in return.

"Mikes" are not rare. In fact they occur almost everywhere. They have been reported from the roots of hundreds of different kinds of woody or perennial plants. In the seventy-five years since Frank first called them to the attention of botanists, Germans, Swedes, Americans, Australians, Britishers, Japanese have described some form of them in their native lands in over eight hundred papers scattered through the botanical journals of the world. In the four states of Pennsylvania, New Jersey, Delaware and Maryland investigators from the Allegheny Forest Experiment Station in 1931 found only one woody plant—the rather rare (for this region) Canada yew—which does not normally bear mycorrhizae on its roots. No wonder that many botanists have seen them and speculated upon their behavior! What

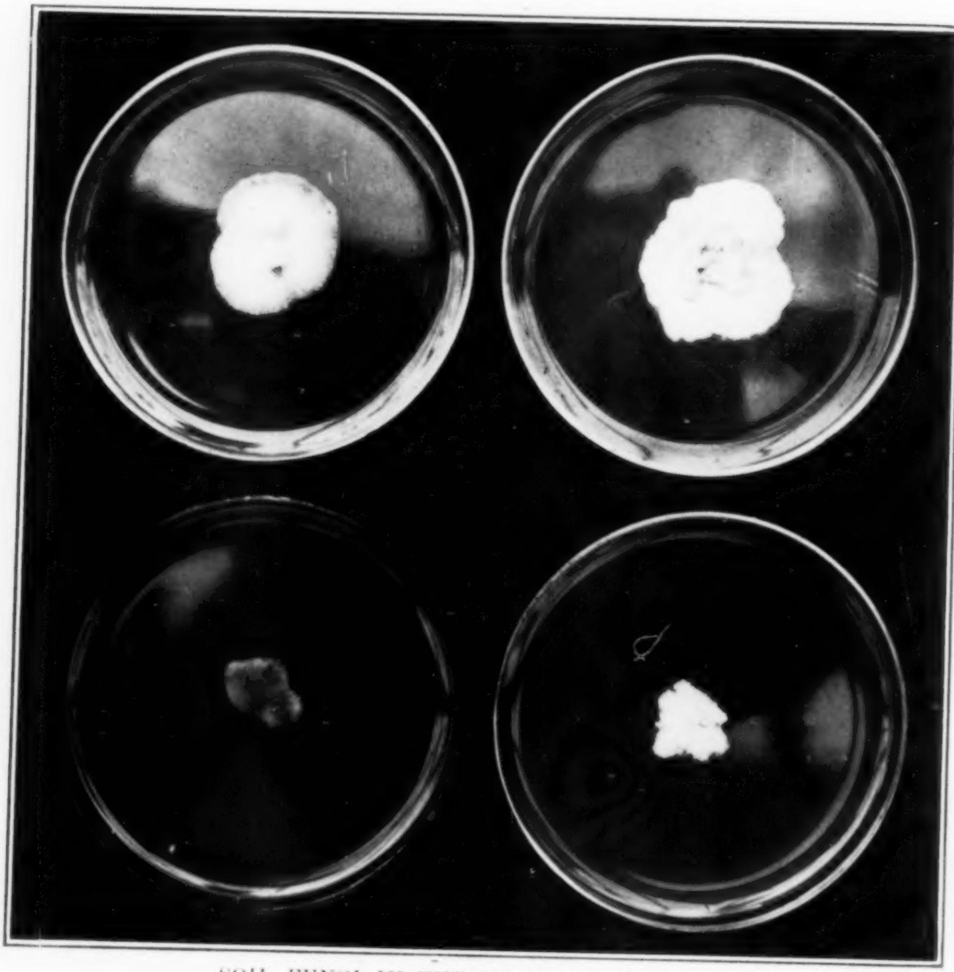


ABOVE GROUND, THE MUSHROOM; BELOW GROUND, THE "MIKE"

*(Upper left.)* THIS MUSHROOM, OR FRUITING BODY, OF THE SOIL FUNGUS *Russula sanguinea*, IS ATTACHED AT THE SOIL SURFACE TO THE THREAD-LIKE MYCELIUM, OR VEGETATIVE PORTION OF THE FUNGUS, WHICH PENETRATES THE SOIL IN ALL DIRECTIONS, SOMETIMES TO A DISTANCE OF SEVERAL YARDS. *(Lower left.)* WHEN THE MYCELIAL THREADS OF THE FUNGUS ENCOUNTER THE ROOT SYSTEM OF A TREE THEY COVER THE SMALLEST ROOTS COMPLETELY, FORMING MYCORRHIZAE ("MIKES"). HERE THE SOIL HAS BEEN OPENED, AND THE MYCORRHIZAL ROOTS EXPOSED. *(Upper right.)* THIS IS A CLOSE-UP OF A LOBLOLLY PINE ROOT AND ITS FORKED MYCORRHIZAE. *(Lower right.)* THIS IS A CLOSE-UP OF MUCH BRANCHED MYCORRHIZAE OF WHITE PINE.

is wonderful is that very few of those scattered over the six continents have sought with determination to read one of the most intriguing riddles in nature. No less a question is involved than whether the majestic oak and the towering redwood are independent organisms, capable of attaining their mighty stature and venerable age through their own efforts alone, or are as impotent as men would be if they had no intestinal bacteria to promote the process of digestion.

No simple investigation is likely to give a thoroughly reliable answer to this question. Trees prosper—or languish—because of so many conditions in nature that it is very dangerous indeed to pick out one particular factor, such as the amount of moisture in the soil, the intensity of light on their crowns, or a hostile insect, plant or animal, and say that it is solely or even chiefly responsible for their condition. And it is particularly hard to study what goes on below ground, where in eternal darkness and in comparative cold the roots of plants avidly seek the life-giving moisture that was yesterday rain or last win-



SOIL FUNGI IN THE VEGETATIVE STAGE

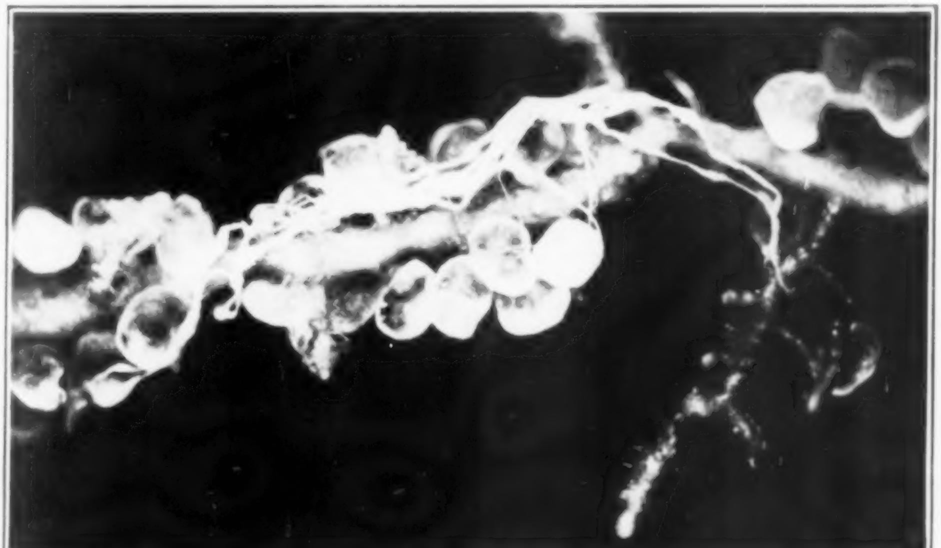
EACH COLONY IS MADE UP OF A DENSE MASS OF MYCELIAL THREADS AND HAS GROWN FOR 14 DAYS ON MALT AGAR IN DISHES. THE TWO ABOVE HAVE BEEN FOUND TO FORM MYCORRHIZAE WHEN PLACED IN CONTACT WITH THE ROOTS OF TREES; THE LOWER TWO HAVE SO FAR NOT DONE SO. MORE THAN 125 SPECIES OF SOIL FUNGI ARE MAINTAINED IN "PURE CULTURES" AT PHILADELPHIA BY THE U. S. BUREAU OF PLANT INDUSTRY.

ter snow. To be quite sure that a particular fungus which grows on the roots of a tree is hurting or benefiting it, we must compare the behavior of this tree with that of another tree growing under precisely similar conditions, but without the fungus on its roots. And because some kind of a soil fungus has formed mycorrhizae on the roots of apparently nearly all trees, some of which prosper and some of which do not, the investigator at the very beginning must learn to identify the different kinds of fungi.

The fungi known as mushrooms are among the most frequent formers of mycorrhizae. The plant pathologist calls them mushrooms, but they include many other kinds than the familiar edible mushroom of our fields, markets, and (alas!) tin cans. Among their close relatives are the puffballs, and in Europe a certain kind forms the truffles which

tickle the palate of epicures, and which tradition says was brought to their attention by the rooting in beech woods of that robust trencherman, the hog. At quite the other end of the scale of edibility, the deadly Amanita, or Death Angel, likewise forms mycorrhizae, as do a large number of other species between these extremes. Some are yellow, some red, but white is the most common color of all. I am referring now to the mushroom itself, the fruiting body or sporophore of the fungus. Mushrooms are borne at certain seasons of the year on the gossamer threads of the mycelium, which have penetrated the soil like roots of a higher plant, but are quite as much the stem and branches as the roots of the fungus. It is the mycelium which, upon encountering the roots of a tree, forms a mantle over the slow-growing side roots that in annual plants develop into root hairs, and also pushes between the outer cells of the tree roots. (Some fungi actually penetrate the root cells; see the photographs.)

Unfortunately, the mycelia of most of the mycorrhizae-forming soil fungi look precisely alike, so that it is generally quite impossible to tell from an examination of the mycorrhizae themselves what fungus is present. Of course, if in a pine grove one finds numerous mushrooms of a certain kind of fungus above ground, and abundant mycorrhizae on the pine roots below ground, one is certainly justified in the suspicion that that particular fungus formed the mycorrhizae on the pine. Once in a great while, perhaps, it would be possible by very delicate excavation to trace a strand of mycelium from the mantle on the pine root to the mushroom on the surface of the ground, thus turning the suspicion into something approaching a certainty. In all other circumstances it would remain a suspicion only. The soil fungus responsible for the mushroom might be quite incapable of mycorrhiza formation, and the fungus investing the pine roots might produce no fruiting bodies at that season or in that year.



FRIEND OR ENEMY?

STRANDS OF THE SOIL FUNGUS, *Lycoperdon gemmatum*, FOLLOWING THE ROOTS OF A PITCH-PINE SEEDLING, ARE AS THREAD TO ROPE IN SIZE. THE MARBLE-LIKE OBJECTS ARE GRAINS OF SAND. NOTE THE SMALL ROOTS AT THE RIGHT.

CULTURE FLASKS CONTAINING VARIOUS SPECIES OF TREE SEEDLINGS BEING TESTED WITH FUNGI FOR MYCORRHIZA FORMATION

THESE FLASKS ARE ARRANGED ON RACKS IN THE GREENHOUSE TO RECEIVE PROPER LIGHT BUT ARE TRANSPORTED TO STERILE CULTURE CHAMBERS IN THE LABORATORY FOR CHANGE OF NUTRIENTS. SOME OF THE SEEDLINGS HAVE GROWN IN THE FLASKS FOR SIX MONTHS. GREENHOUSE OF THE ALLEGHENY FOREST EXPERIMENT STATION, A FEDERAL UNIT HOUSED ON THE CAMPUS OF THE UNIVERSITY OF PENNSYLVANIA.

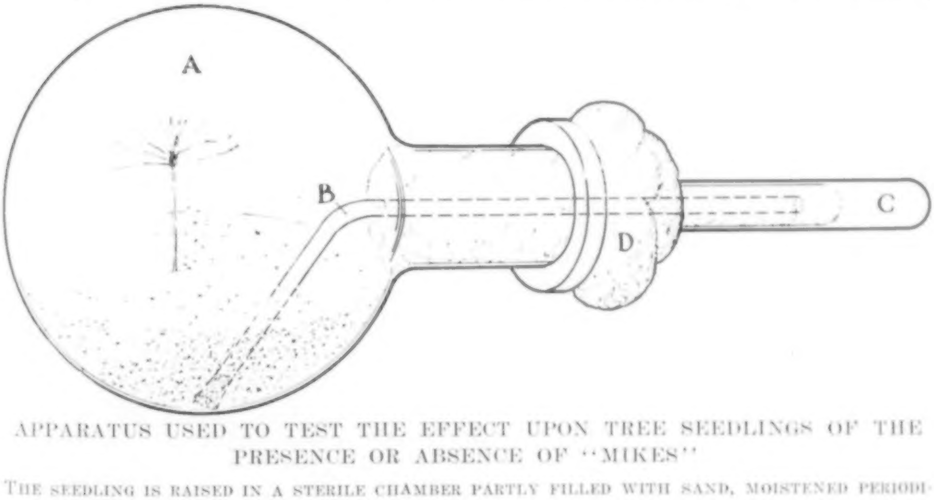
The process of identifying the fungus forming the mantle on a tree root is a long and tedious one. The first step consists of making what is known as a pure culture of the mantle. A tiny piece of the mantle must be removed and, with the least possible exposure to the air, divided between several test-tubes half filled with agar, a substance on which fungi generally thrive. (Glass dishes are sometimes substituted for the test-tubes. See the illustration.) In a few days or weeks there grows on the surface of the agar and on the sides of the test-tube a mass of mycelia, often quite characteristic in color, shape, texture, or other feature. The growth in all the test-tubes inoculated from one mantle must be identical, or contamination by some other fungus or perhaps a mould is suspected. This growth is then painstakingly compared in its appearance and structure with the growth, in similar test-tubes, of fungi previously cultured from mushrooms, which alone of all the parts of a soil fungus may be distinguished with comparative ease and classified. If the test-tube formation cultured from a mycorrhiza is identical with that cultured from a mushroom, the same fungus is responsible for both.

The Bureau of Plant Industry investigators at the Allegheny Station now have a collection of over 125 cultures of soil fungi suspected of forming mycorrhiza, all painstakingly "raised" from different kinds of mushrooms. The chances are good that the culture from a mycorrhizal root obtained in the station territory will prove to be identical

with one of these 125 and can thus be identified. This collection of cultures is therefore a valuable one and justifies the unremitting care that it demands. Some soil fungi are very hardy, growing vigorously in the agar of the test-tubes for weeks without any attention. Others will languish and even die within ten days if not transferred to new agar in a new test-tube. Just why they behave in these ways no one knows, yet many of their food requirements have been determined experimentally.

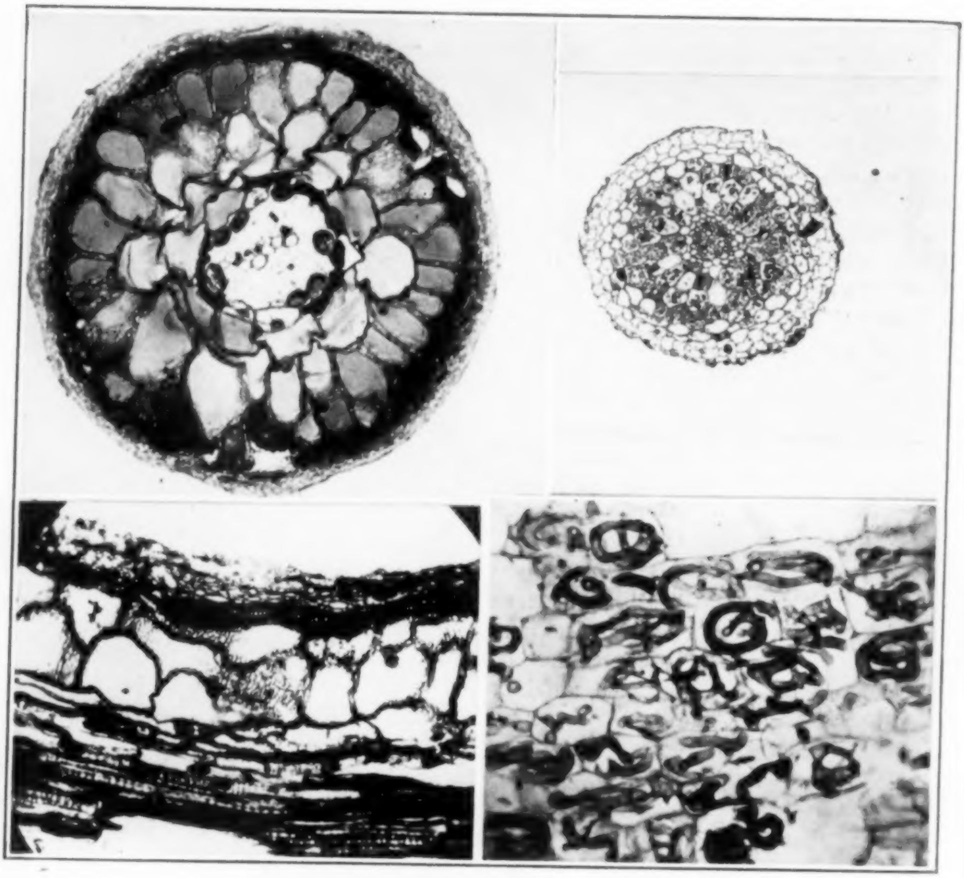
But the real investigator is not satisfied to have identified his mycorrhiza-forming fungus in this way. He will not report the identification as authentic until he has succeeded in re-infecting the particular tree involved with the test-tube fungus. To do this with certainty he must inoculate a seedling of this tree with the fungus under otherwise perfectly sterile conditions—that is, free of every contamination by bacteria, mold, or fungus except the one he is working with, and must keep it growing under these conditions long enough for mycorrhizae to form on its roots.

The process requires of the investigator both ingenuity and great manual dexterity. Because in the woods, and even in the nursery or greenhouse, the tree seedling from the very day of its germination is attacked by a host of living organisms both above and below ground, the student of mycorrhizae must raise his tree from sterilized seed right in the sterile chamber where it is to grow. The chambers—sizable glass flasks with very carefully fitted stoppers—are partially filled with pure white sand, and then thoroughly steam-sterilized to destroy all life within them and the sand. The seed of the tree, sterilized previously and tested for sterility on agar in test-tubes, and a bit of mycelium from the culture of the fungus, are then swiftly transferred in a sterilized atmosphere to the sand in the chamber, and the stopper is tightly fitted. Glass tubes, permanently inserted in the stopper, reach to the bottom of the sand in the chamber, as shown in the illustration, and through these distilled water, in which essential plant foods are dissolved, is introduced into the sand; any surplus is removed by suction. The whole apparatus is then set in a sunlit greenhouse. The seedlings




APPARATUS USED TO TEST THE EFFECT UPON TREE SEEDLINGS OF THE PRESENCE OR ABSENCE OF "MIKES"

THE SEEDLING IS RAISED IN A STERILE CHAMBER PARTLY FILLED WITH SAND, MOISTENED PERIODICALLY WITH A NUTRIENT SOLUTION INTRODUCED BY MEANS OF A GLASS TUBE PASSING THROUGH THE COTTON PLUG CLOSING THE NECK OF THE FLASK. THE WHOLE APPARATUS IS HANDLED WITH EXQUISITE CARE TO PREVENT CONTAMINATION BY SPORES OF ANY ORGANISM EXCEPT SUCH FUNGI AS MAY BE DELIBERATELY INTRODUCED ALONG WITH THE TREE SEED.



"MIKES" UNDER THE MICROSCOPE

(*Upper left.*) CROSS-SECTION OF A FINE ROOT OF LOBLOLLY PINE, COMPLETELY SURROUNDED BY A LIGHT-COLORED MANTLE OF MYCELIAL THREADS, WHICH ALSO PENETRATE *between* THE CELLS OF THE ROOT. SUCH A MYCORRHIZA IS CALLED "ECTOTROPHIC." (*Lower left.*) LONGITUDINAL SECTION OF A SIMILAR ROOT. AT THE TOP IS THE MANTLE, AT THE BOTTOM THE CENTRAL CELLS OF THE TREE ROOT. THE GRANULAR APPEARANCE OF THE LARGE CELL IN THE MIDDLE IS DUE TO A CHANCE PASSAGE OF THE SECTIONING BLADE THROUGH A LAYER OF MYCELIUM SEPARATING TWO CELLS. (*Upper right.*) CROSS-SECTION OF AN "ENDOTROPHIC" MYCORRHIZA OF TULIP POPLAR. HERE THERE IS NO MANTLE SURROUNDING THE TREE ROOT, BUT THE MYCELIUM OF THE FUNGUS HAS ENTERED ITS LIVING CELLS, IN WHICH THE STRANDS APPEAR IN CROSS-SECTION AS TINY CIRCLES. (*Lower right.*) A LONGITUDINAL VIEW OF THE PRECEDING, FURTHER ENLARGED. THE WORM-LIKE OBJECTS ARE PORTIONS OF THE HYPHAE, WHICH HAVE PENETRATED THE CELL WALLS OF THE TULIP POPLAR ROOT AND ARE COILED WITHIN MANY OF THE CELLS.

grow for many months, completely protected from contact with every other living thing than the soil fungus with which the sand was inoculated. From time to time one of the flasks is removed from the experiment and the roots of the seedling are microscopically examined with exquisite care for the presence of mycorrhizae. Sometimes the fully developed mycorrhizae can be seen in the sand against the wall of the flask. Discovery of them completes the identification of this particular fungus as a mycorrhiza-former on this particular species of tree.

The same process and the same apparatus are counted upon some day to yield the final answer to the riddle of mycorrhizae—whether they are helpful or harmful to the tree on the roots of which they occur. Some of each batch of seedlings are not inoculated with any fungus, and their behavior is compared with that of inoculated seedlings. A variety of nutrient solutions are fed to all the little trees alike; they include both organic and inorganic salts containing nitrogen, phosphorus and potassium, which of all the elements required by plants are most likely to be deficient in soils, and the lack of which produces the most prompt and marked effects on plants. The action of the teeming microscopic flora—bacteria and fungi—upon nitrogenous matter in the soil is most complex, and their endless reactions are of even greater complexity. Inorganic nitrogen, such as so-called commercial fertilizers contain, is easy for trees and other higher plants to assimilate, but most forms of organic nitrogen are very hard. Fungi, on the other hand, are quite able to obtain the nitrogen they need from organic sources, such as decaying plant material, and in so doing they may convert it into forms usable by higher plants.

It is this latter possibility that investigators of mycorrhiza-forming fungi believe to be the key to any beneficial effect these fungi may have on trees. To test this possibility they furnish some of their seedlings in the flasks with inorganic nitrogen only, and others with organic only. The signs of nitrogen starvation in seedlings are spindly stems, short and twisted needles, pale green at first and eventually yellow, and reduction in extent of the root system. If after several months certain batches of seedlings should show unquestioned signs of nitrogen starvation in comparison to others, the differences in behavior can be ascribed to the presence or absence of mycorrhizae. The expectations are that the seedlings furnished with inorganic nitrogen will develop satisfactorily either with or without mycorrhizae, unless of course the fungi are definitely harmful; and that those furnished with organic nitrogen will do better if inoculated with mycorrhiza-forming fungi.

Unfortunately the symptoms of nitrogen starvation do not appear at once (distilled water alone, plus air, will allow a newly germinated pine seedling to grow for several weeks) and are obscured somewhat by the unnatural conditions which the seedlings encounter in the flasks—an atmosphere saturated with moisture, light changed in many of its qualities by passing through the glass of the greenhouse and that of the flask, temperatures probably higher than in nature, and complete absence of the great complex of other living things—some of which in the woods undoubtedly react favorably, both above and below ground, to tree seedlings. Furthermore, it is by no means certain that nitrogen assimilation alone is involved; Frank and many students felt that the intake of the essential inorganic nutrient salts, and even of water itself, were influenced by mycorrhizae. The sum total of all these influences, some of which may be unfavorable while others are favorable, might well affect the growth of the seedlings less strikingly than if only one were at work. At any rate, few investigators dare hope for such spectacular results as the speedy death of seedlings having no mycorrhizae, and the vigorous growth of those which have, or *vice versa*. Nature's processes are so subtle, and life is so inscrutable a thing, even to-day, that it is only the layman who expects them to become plain as a pikestaff.

Where trees grow not in the greenhouse but in the forest, it seems reasonable to assume that the environment, particularly the physical and chemical characteristics of the soil, its moisture and aeration, and the relation of the mycorrhizal fungus to non-mycorrhizal fungi and to bacteria, will determine the

balance of power between tree and fungus.

But of what practical value, one may reasonably ask, will be the knowledge that mycorrhizae help or harm the higher plant? After all, it may be argued, can man exert any appreciable control over the flora of the soil? On a large scale, perhaps not. But under certain conditions at least it should be possible to destroy mycorrhiza-forming fungi if they be harmful or to foster them if they be beneficial. Devices for steam-sterilization of the seed-beds in tree nurseries have been developed which will destroy the soil flora to a depth of several inches, and the soil fungi may not invade the sterilized beds for several years. Inoculation of beds with fungi found to be beneficial formers of mycorrhizae also seems quite feasible.

Some very striking results with soil inoculation have in fact been obtained by students of mycorrhizae in England recently and in Australia some years ago. The Royal Forestry Commission attempted in 1924–27 to reforest dreary Wareham Heath in Dorsetshire, England, by sowing several kinds of pine, generally with very disappointing results. The seed germinated well, but nearly everywhere the seedlings died after two or three years of feeble growth. Experimental areas in later sowings, inoculated with small quantities of soil brought from vigorous stands of the same pines as those planted and known to contain mycorrhiza-forming fungi, were reported to produce seedlings notably more vigorous than untreated areas adjacent. In Australia the introduction of forest soil into a tree nursery on land never before forested produced an immediate change for the better in the growth of seedlings; the result was attributed to mycorrhizae. American investigators, however, have not been quite so willing as their English cousins to attribute the better growth of the young trees in these experiments to mycorrhizae. They point out that the soil inoculum almost certainly contained many more species of organisms than the fungi which admittedly formed abundant mycorrhizae on the vigorous seedlings, and were mostly absent from the stunted ones. The Allegheny Station investigators share the presumption that the abundance accounted for the vigor, but point out that there is nothing to prove that both were not the result of some favorable soil condition—increased numbers of bacteria of certain kinds, for example—that was introduced along with the mycorrhizal fungi. The increase in mycorrhiza production may not be the cause of better growth; rather it may follow as a natural consequence of the increased growth, especially of the roots, regulated by other organisms or by chemical changes in the soil.

Should mycorrhizae prove harmful, there is some possibility of control by better methods than the steam-sterilization just mentioned. The steam, unfortunately, kills all species of soil organisms indiscriminately. Certain chemicals might be found to kill selectively—to eliminate the mycorrhizal fungi and spare non-mycorrhizal fungi and bacteria. The fact that some non-mycorrhizal soil fungi have been shown to attack and destroy the mantles of mycorrhiza-formers suggests their use for this very purpose. The latest development in control of the potato scab is inoculation of scab-infested fields with a fungus hostile to the scab. Perhaps the balance of activity of soil organisms, including mycorrhizal fungi, can be regulated in like manner.

# PIONEERS IN THE STUDY OF VIRUS DISEASES OF PLANTS

By Dr. MELVILLE T. COOK

PLANT PATHOLOGIST, AGRICULTURAL EXPERIMENT STATION, RIO PIEDRAS, PUERTO RICO

Most people are interested in the work of pioneers in new countries and in the study of new subjects. Our interests may lie in their adventures or in the new ideas which they suggest. Some pioneers in new fields of study have been in as great danger of criticism and ostracism as their brother pioneers in new countries have been of losing their lives. The heroism of these people always appeals to us, but sometimes the delay between the achievements of these pioneers and the recognition of their achievements has been so great that much of the true personal viewpoint is lost. Very frequently the recognition due these workers does not come until they have passed away, and sometimes it is difficult to determine just who are the true pioneers and credit is sometimes given to the showmen or the brilliant writers rather than to the true workmen. This statement may apply to many classes of people, but the writer has in mind the great scientists of the world who have been leaders. Very few have suffered the fierce criticisms that were fired at Darwin, but many of them have not been recognized until many years after they have passed from the scenes of their labors. The purpose of this paper is to call attention to a group of workers, many of whom are living and active in their researches. They are true pioneers in a new branch of plant pathology.

There are three well-defined branches of plant pathology: (1) diseases caused by fungi, (2) diseases caused by bacteria and (3) diseases caused by viruses. To these may be added a fourth branch to include the various non-parasitic and deficiency diseases which are frequently referred to as physiological. The diseases caused by viruses were at one time placed in this last group by many students. This group is not well defined or well developed. The first and second branches are deep rooted in the past, but the great advancement has been within the last three quarters of a century. The third is a new branch; in fact, it is so new that we are not sure that we know the nature of the causal agents which we call viruses. This new branch has its pioneers, and it is well that we should give them some consideration at this time. These men have not suffered the criticisms that fell to those who pioneered the fields of evolution a few years earlier, but they are true pioneers who have opened the trails for a new branch of science.

The writer fully appreciates that different workers may have different ideas as to the date for the ending of the pioneer period and as to who should be included in the list of pioneers. The writer has arbitrarily placed 1920 as the end of the pioneer period and has selected four Europeans, four Americans who appear to him to be the outstanding research pioneers in this new branch of plant pathology, which we have designated as "virus diseases." The selection of 1920 as the date for the ending of the period appears to the writer to be justified by the literature. In the opinion of the writer the four outstanding Europeans are Mayer, Iwanowski, Beijerinck and Quanjer. The four outstanding Americans are E. F. Smith, Woods, Allard and James Johnson, although several others contributed much to our knowledge of the subject during this period. These men have been selected because they started lines of research which attracted

ADOLPH EDWARD MAYER

and stimulated studies in this branch of plant pathology. It does not include the names of early workers who reported new diseases.

A few virus diseases had been reported long before any of these men began their studies, but in most cases they were not recognized as diseases. They had attracted the attention of horticulturists and a few others who were interested in plants. Some of them were recognized as injurious to economic plants, but in some cases the symptoms were considered of value in floriculture. The breaking in tulips and the mottlings in *Abutilon Thompsonii* are striking illustrations in which the symptoms were considered of value. The mosaic of tobacco in Europe and the peach yellows in the United States were the two injurious diseases that finally forced scientific research.

Adolph Edward Mayer was the first of these pioneers, and the researches into these problems started with his studies. A peculiar mottling of tobacco had been known for a long time and finally became of such great economic importance that Mayer was called to make a study of the problem. The first work was done at an agricultural experiment station in Holland (Rysproef Station Zu Wageningen). Mayer's task was gigantic for the times, and his results show him to have been a true research scientist. He published the first truly research papers on a virus disease. Influenced by the studies in bacteriology which had come into prominence, he believed that these minute organisms were the cause of this mysterious disease. This theory proved to be wrong, but he appears to have been the first to make inoculation, temperature, transmission and dilution studies. He also did some work on transmission by budding. He suggested the name "mosaickkrankheiten," which has been translated into and used in other languages. He pointed the way for research workers.

Dmitri J. V. V. Iwanowski was the second European to attract attention. He was also a believer in bacteria as the

DMITRI J. V. V. IWANOWSKI

cause of tobacco mosaic, but he is known as the first worker to demonstrate that the active agent would pass through a filter that would remove bacteria. This epoch-making discovery was made in advance of the corresponding work by the students of the virus diseases of animals. Also, he was the first to observe the presence of the intracellular bodies in diseased plants, and he believed them to be the results of the disease. A few years later these bodies attracted much attention and some workers believed them to be protozoan in nature and the causes of these diseases, but many workers are inclined to agree with Iwanowski. He studied the structure of diseased plants, reported crystalline bodies and crystals.

Martinus Willem Beijerinck confirmed much of the work of Mayer and Iwanowski and was the first to reject the bacterial theory which brought him into controversy with Iwanowski. He will be remembered as the author of the "contagium vivum fluidum" theory. Although this theory was abandoned long ago, it started research work that has been very fruitful. His influence on research was as great or greater than that of either of the other two. His confirmation of the filtration studies of Iwanowski was made in the same year (1898) that Loefler and Frosch demonstrated that the active agent of foot and mouth disease of live stock would pass through a filter and helped to bring that line of research into prominence. He also studied the structure of the diseased plant and was the first to suggest that the active agent traveled through the phloem. He appears to have been the first to study the effects of chemicals on the active agent.

MARTINUS WILLEM BEIJERINCK

HENDRIK MARIUS QUANJER

A study of the literature reflects the enormous influence of these three men on the study of these diseases for many years. In fact, many of their studies are repeated by students of to-day in the studies of other virus diseases, and some of their discoveries are very generally accepted to-day.

Hendrik Marius Quanjer was the next European to initiate important researches

ERWIN F. SMITH

in Europe. He contributed much to our knowledge of the virus diseases of plants, especially potatoes. In 1908 he started his extensive studies on the necrosis of the phloem tissues of potatoes which have explained some of the phenomena of the virus diseases on this and other important crops. His studies have suggested lines of research to many students of these diseases.

Erwin F. Smith holds a position in America comparable to that of Mayer in Europe. He made the early research studies and compiled records on peach yellows from the time of its discovery down to the time of the publication of his report in 1888. He made studies and demonstrated facts concerning its transmission by budding that are accepted at this time. He was primarily a bacteriologist in the field of plant pathology and was influenced by his studies in that subject and probably by the work of Beijerinck as shown by this paragraph.

"The spread of yellows from diseased buds to healthy stocks, which I have carefully verified, points strongly to some *contagium vivum* as the cause of the disease. If a micro-organism be really the cause, it probably occurs quite constantly in some part of each diseased tree, and this must be established beyond question; it must be clearly distinguished from similar organisms not related to the disease; and, finally, it must be isolated by cultivation in suitable nutritive media and be able to produce the disease when inserted into healthy trees. If from a pure culture of some micro-organism peach yellows can be induced in healthy trees, then the case is closed and there can be but one verdict."

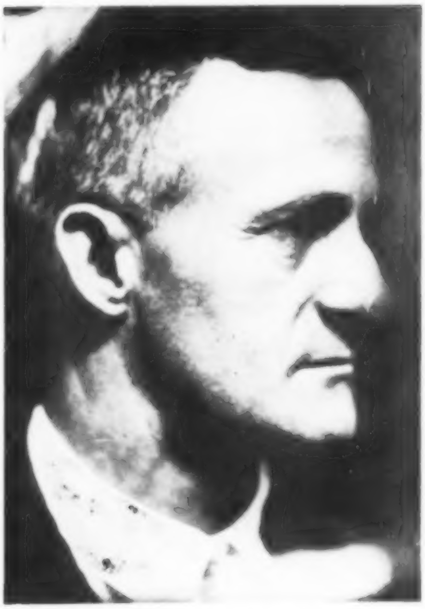
He was the discoverer of the "little peach" disease and made studies similar to those on "yellows." He confirmed the work of horticulturalists who claimed that this disease could be transmitted by budding and demonstrated it was not transmitted through the soil and very rarely by the seeds.

He made a translation of some of the work of Mayer which shows the thoroughness of his attack on this problem at a time when few virus diseases were

ALBERT F. WOODS

known and their relationships not suspected. I am told that in his later years he said that his failure to discover the cause of "peach yellows" was the greatest disappointment of his life.

Albert F. Woods was the next American worker to attract our attention, and he will be remembered as the originator of the enzyme theory. He was influenced by the studies on enzymes which were attracting so much attention at that time. He advanced this theory as an explanation of the cause of tobacco mosaic. This theory was very generally accepted at that time and for several years. Although this theory has very few advocates at the present time it was a great stimulus to research. Very recent studies on the chemistry of virus diseases by Vinson and Petri (1927–34), Barton-Wright and McBain (1933), Stanley (1935–36) and others have again brought this theory into some prominence. In this connection it is interesting to know that Hunger (1902–08) and Baur (1904–09) made studies on the



HARRY A. ALLARD

JAMES JOHNSON

causal agents and that both came to the conclusion that these agents were nonliving and that they increased in amount in the cells of the host plants.

Woods also made inoculation studies and was the first to demonstrate that tobacco mosaic would attack Petunia. He was the first to report mosaic on *Phytolacca decandra* and tomato. He also published (1897) a paper on a disease of carnation known as "stigmonose," which was probably a virus disease, and called attention to the aphis and other insects associated with it in a causal way. In the same year he published a report on the Bermuda lily disease, which is now known to be caused by a virus.

Harry A. Allard is the third American in my list of pioneers. His studies were almost entirely on the mosaic disease of tobacco. He made many cross inoculations and was the first American to make studies on dilution and filtration of the sap of diseased plants. He also studied the malformations of the flowers of mosaic tobacco plants. He rejected the en-

zyme theory of Woods, but believed that the disease was due to an ultramicroscopic organism. He appears to have been the first to suggest that some diseased plants were symptomless carriers, a fact which did not attract much attention until Nishimura published his paper on *Physalis alkekengi*. He followed the suggestion made by Clinton and demonstrated that an injury to a healthy plant was necessary before it could be infected by juice applied on the surface and that washing the hands of the laborers who were working with plants would remove the active agent and prevent much of the infection. The series of papers published by Allard became the foundation of much of the work that was to follow.

James Johnson was the next American to attract attention as a pioneer by his research studies and will be remembered for his experimental work on the effects of temperature on the symptoms of virus diseases. Some of the other early workers had made studies on the influence of environmental factors on these diseases, but the methods were not nearly so satisfactory as those used by Johnson. His studies became the basis of much of the work by other students of this subject.

It is very interesting to note that six of these pioneers studied the mosaic disease of tobacco, a disease which is still the subject of much important research work. One studied diseases of the peach and one studied diseases of the potato.

There were several other research workers who were studying virus diseases during this period and the following period who should probably be classed as pioneer workers. Some of them made contributions and others made observations and suggestions which have stimulated studies by others.

W. A. Orton was a pioneer in the study of the virus disease of potatoes and laid the foundation for much of the experimental work of more recent investigators. His studies consisted primarily of field observations, but he stimulated research by other workers. He discovered the mosaic disease of potatoes in Germany in 1911 and upon his return to America found that the disease was abundant in his own country. His influence was very evident in both America and Europe.

George P. Clinton's early work on tobacco was not extensive but was basic. The ease with which tobacco mosaic could be transmitted from plant to plant was known long before he began his studies, but he was probably the first to suggest that there was some connection between bruising of the glandular hairs and the transmission of the causal agent and that requiring the laborers to wash their hands with soap and water would remove the active agent and reduce infections in the seed beds and fields. This was confirmed by Allard, who demonstrated that ordinarily the disease was not transmitted unless the healthy plant had been subjected to slight injuries. He appears to have been the first to demonstrate the transmission of mosaic between tobacco and tomato.

This paper would be incomplete if we did not mention the pioneer studies on the transmission of the viruses by means of insects. The first proof of transmission of insects comes from Japan and the studies were made by Hashimoto and Takata (1894–96) on the transmission of the stunt disease of rice by an insect now known as *Nephotettix apicalis*. The next pioneer studies were made in America by Ball, Adams, Shaw, Townsend, R. E. Smith, Bonequet and others over a period extending from 1906 to 1917. A more complete discussion of the studies by these workers will be found in a paper in this journal for February, 1937.

Much important work has been done since 1920, and our knowledge of the subject has increased very rapidly. The next few years will undoubtedly bring forth a large number of important papers and may change our views on the viruses and probably on the characters of the simplest forms of life.

# THE FAT OF THE LAND

By Dr. B. W. KUNKEL

PROFESSOR OF ZOOLOGY, LAFAYETTE COLLEGE

It is more than a poetic fancy that "all flesh is grass," as the prophet of old exclaimed, for the nutrition of all animals is derived from the green plants and can be traced to the process of photosynthesis. From the amoeba to man and the mammoth there is a complete dependence upon the products of green plants. Every bit of energy which they exhibit is the result of the oxidation of fuels produced by green plants. Besides this they furnish also the complex building materials necessary for growth and repair. It is the chlorophyll of the green parts of plants which absorbs radiant energy of the sunlight and transforms it into the energy of complex chemical compounds. This is the familiar process of photosynthesis. It is not a highly efficient process, for only about 2 per cent. of the radiant energy reaching the plants can be recovered from them by oxidation of the products of photosynthesis, and yet there is no energy lost—the rest simply warms the surroundings and is radiated into space.

The question I wish to discuss is: How much "grass" can be grown on a unit area; what is the maximum productivity of an acre in terms of food for man?

If we go back far enough in the world's history we find that there were no animals but only bacteria and green plants. The green plants represented a great advance over the bacteria because they were able to tap stores of energy which were locked against the bacteria and were well-nigh inexhaustible. The evolution of chlorophyll enabled these plants to absorb energy from sunlight and retain it indefinitely in the form of complex starches, cellulose, etc. From that time energy began to accumulate in these complex chemical bodies. The evolution of animals represented a further step in advance, for these creatures utilized the concentrated stores of energy synthesized by the green plants, oxidizing the proteins, carbohydrates and fats. They also were relieved of the complex process of manufacturing amino acids as a first step in the building up of protein. Thus, the animals digest proteins to amino acids and then pile these building stones in to new and individual patterns of protein and oxidize the fuels which were laid up by the plants.

Indeed, the whole evolutionary process, from the earliest appearance of life, has been to appropriate more and more energy of one kind or another; so that it can later be expended in heat, motion or other kind of kinetic energy more abundantly.

The growth of the blade of grass upward and its root downward, the laying down of layers of limestone by the coral polyps, the lengthening of the muzzle and the limbs of the ancestral horses, the cerebration of the philosopher and the labor of farmer and miner are all concrete illustrations of the thirst for energy exhibited by living things. In the last analysis all the activities of living things can be referred back to this demand for solar energy, for even the reproductive urge is for the purpose of increasing the number of absorbers of solar energy.

The most economical path by which solar energy is taken up by animals is directly from green plants, for it is obvious that when one animal feeds upon another animal it secures only the quantity of energy which is present in the

body of its prey at the moment, the great bulk of the food consumed by the prey has already been oxidized in the life processes, and the products of the combustion have been discharged into the great outside world and are lost so far as the feeder is concerned. These waste products in part may be ready to be resynthesized at once by the green plants; namely, the carbon dioxide and water. The nitrogenous wastes, on the other hand, must be acted upon by a variety of bacteria before they are again available as food for the green plants. These bacteria are the organisms which cause rotting of protein and the putrefaction of the excreta of the body. They oxidize vast quantities of these complex organic compounds in order to liberate energy for their own activities.

At the same time that it may be more economical to utilize the substance of plants directly for fuel than indirectly from the bodies of other animals, the physiological economy of the human body is probably served best by a mixture of animal and plant material in the diet. As will be seen later, however, this is very uneconomical of land. This wastefulness of the original solar energy falling upon a unit area may be illustrated best by following the course of the diet of the Eskimo to its origin. The Eskimo lives largely upon seal meat. The seal feeds upon fish, the fish upon snails and other invertebrates and these in turn upon seaweeds. As a growing child eats its own weight every ten days and the adult eats nearly four pounds of food a day or between 2 and 3 per cent. of his body weight a day it is evident that the Eskimo must consume many seals in the course of a year to keep going; certainly, while growing he must consume upwards of five pounds of food in order to increase his own weight one pound. Although the experiment has not been actually made to determine how much food must be consumed by the seal to gain a pound in weight, it must be essentially the same—that is, the five pounds of seal is obtained from twenty-five pounds of fish. Although the fish does not have to maintain a body temperature considerably higher than its surroundings, it may not have to consume as many pounds of food in order to gain a pound in weight. This estimate is so close to the maximum power of converting food into flesh exhibited by the prize swine which have been developed by careful selection (three pounds of food for one pound in body weight) there may be justification in retaining this ratio. The twenty-five pounds of fish therefore represent 125 pounds of shrimps, and this amount of shrimp required five times as much algae for their upbuilding. Thus each pound of Eskimo by this circuitous route of obtaining plant material is at the cost of 625 pounds of algae. This very wasteful food cycle is one of the reasons why the Arctic regions are incapable of supporting more than their sparse population. The population of Iceland is only about two per square mile for the whole area or one to 320 acres. This is not, however, a perfectly fair statement, for the Icelanders are not agriculturists. They are largely fishermen, getting most of their food from the surrounding water. But even in the Belgian Congo, where the solar energy is almost a maximum, there is an estimated population of only about one to sixty-four acres in contrast to the United States, where there is a density of population of one to fifteen acres. The sparse population of backward parts of the world is to be explained partly by the fact that man is able to utilize only a very small portion of the vegetation for food. The whole practice of agriculture, indeed, is the replacement of useless or noxious organisms by useful ones.

Whether the agricultural phase of

civilization is sooner or later to be replaced by the factory phase in which foods will all be processed or synthesized under cover in controlled climates and under controlled conditions of all kinds, is a question. It is one of the intriguing problems of biochemistry to synthesize carbohydrates from carbon dioxide and water without the agency of living plants and possibly utilize a larger proportion of the radiant energy of sunlight than the green plants do.

The problem of determining the supporting power of the earth is a difficult one. At the present time the population of the earth is about 1,800 million and the density of population is approximately one person to nineteen acres. This, however, shows us nothing about the real supporting power of the earth, because actually the density of population varies greatly and many parts of the earth are incapable of supporting any human beings. Here in the United States the density of population is one to sixteen acres; in Australia it is only one to 320 acres. The amount of arable land is variously estimated. Sir George Knibbs regards one half of the land area of the world as either too rocky or mountainous or dry or cold or occupied by roads and buildings and cities so that possibly sixteen billion acres may be regarded as arable. East estimates only 40 per cent. as arable or about thirteen billion acres. That is to say, there is enough arable land to allow each inhabitant of the earth from about seven and one fourth acres to nine acres upon which to raise his food and clothing. This, again, is not highly enlightening, for a considerable quantity of food is taken from the forests, the semi-arid grazing lands and the waters of the globe.

Here in the United States the density of population is somewhat greater than that of the earth generally. In 1918 (Year Book of the Department of Agriculture) O. E. Baker and H. W. Strong estimated that only about 413.2 million acres of the total land area of the United States of 1,903 million acres are improved. But these supported a population of about 106 million at the time or one for a little under four acres. This, however, does not take into account the population supported by cattle grazing over the unimproved prairies which cover a vast area in the west, where the rainfall is too sparse to permit an abundant growth of vegetation which would repay the expense of cultivation. East, in his "Mankind at the Cross Roads," estimates that the improved land may be increased, when the population is sufficiently pressing, to 800 million acres. The rest of the 1,903 million acres not devoted to crops includes 360 million acres of woodland and forest, 425 of cattle ranges, 238 of desert and eighty of roads, cities, railway tracks, etc. In addition to a population of 320 million which may by somewhat improved methods be supported on the cultivated land, one man per two and one half acres, East estimates that grazing land will support one man per one hundred acres or a total population of four millions, and the forest and woodland can support one man on fifty acres or seven million in all. The capacity of two and one half acres to furnish food and raiment for one person was arrived at by East on the basis of the intensive agriculture of some of the European countries. He calculated that pre-war Germany cultivated two acres for each man supported, France 2.3 acres and Belgium 1.7 acres.

The ratio of arable land to population in other parts of the world is very diverse, as the figures in Table I indicate.

These figures, of course, do not mean that the menu of the Japanese is raised on a third of an acre. There is much food imported which is paid for by the exports of manufactured goods, and a

TABLE I

| Country | Acres per inhabitants |
|---|---|
| Canada | 28.9 |
| Argentina | 18.5 |
| Russia | 4.2 |
| United States | 3.3 |
| Denmark | 2.2 |
| Roumania | 1.8 |
| Sweden | 1.5 |
| France | 1.3 |
| Italy | 1.27 |
| Germany | 1.1 |
| China | 0.76 |
| Netherlands | 0.69 |
| England | 0.63 |
| Belgium | 0.56 |
| Japan | 0.36 |

considerable part of the food is taken from the sea.

The determination of the relative efficiency of the agriculture of the different countries requires much calculating. One of the best indices is that used in Table II, which is determined on the basis of the average production of the six principal crops—wheat, oats, barley, rye, corn and potatoes—over a series of years. Each crop of each country is weighted in accordance with the percentage of acreage devoted to each crop and the several percentages are then added together. The relative productiveness of the farms of the principal countries is expressed in Table II.

TABLE II

| | |
|---|---|
| Belgium | 221 |
| Holland | 190 |
| Great Britain | 177 |
| Germany | 169 |
| Denmark | 168 |
| Japan | 137 |
| Canada | 136 |
| Chile | 136 |
| Sweden | 128 |
| France | 123 |
| Austria | 120 |
| Hungary | 113 |
| United States | 108 |
| Italy | 96 |
| Rumania | 94 |
| Spain | 93 |
| Argentina | 75 |
| Russia | 71 |
| Mexico | 52 |

In Bulletin 987 of the Department of Agriculture the relative efficiency of agriculture in the several countries may be seen by the average yields in bushels per acre of the crops listed in Table III.

TABLE III

| | Wheat | Corn | Beans | Barley | Potatoes | Rice |
|---|---|---|---|---|---|---|
| United States | 14.3 | 26.3 | 10.1 | 25.6 | 92.7 | 38.4 |
| Great Britain | 31.8 | ... | 27.3 | 32.9 | 213.9 | ... |
| France | 16.5 | 16.8 | 13.3 | 21.4 | 99.0 | ... |
| Italy | 15.0 | 23.7 | 3.3 | 17.4 | 71.1 | 46.5 |
| Japan | 22.6 | 26.6 | 14.2 | 25.0 | 151.6 | 51.8 |

Another comparison of the agricultural capacity of different parts of the earth may be made by dividing the total yield of the principal crops by the total area of the country. The figures for Great Britain and Germany were compiled by Sir Thomas Middleton on the authority of E. H. Starling in "The Feeding of the Nations" (1919). The figures for the United States are taken from the statistics in the *World Almanac* and are for 1925 (Table IV).

The differences in the yield of different countries are to be explained, of course, by the general agricultural practices, such as the choice of seed and selection of cattle, the quantity of fertilizer applied, the amount of water available to the growing plants, the control of pests, climate, etc. Social and economic factors are involved, including the cost of land, cost of labor, etc., but these factors will have to be passed over at this time.

The figures thus far presented show simply the present results of agricultural practice over large areas and with all degrees of intelligence and skill. The application of the same degree of skill and the same efficiency which is applied to large scale manufacturing plants would without doubt result in the reaping of much larger harvests per acre than are represented by the average figures just cited.

In order, then, to determine the maximum yield of foodstuffs per acre, it is necessary to consider some of the princi-

TABLE IV

| | Great Britain | Germany | United States |
|---|---|---|---|
| Persons fed per acre of cultivated land | 0.4–0.5 | 0.7 | 0.12 |
| Wheat (per acre) | 300 lbs. | 660 lbs. | 43.80 lbs. |
| Potatoes (per acre) | 220 | 1100 | 21 |
| Meat | 80 | 90 | |
| Milk | 350 | 560 | |
| Sugar | negligible | 550 | |
| Corn | | | 156 |

ples of plant physiology which limit soil productivity.

In the first place, the plant physiologist and agrobiologist have established the fact that a particular strain of plants can produce a definite yield beyond which all the nursing and feeding and culture can not push it. It is the same principle which we see all about us among the animals. There is a limit of growth which can not be surpassed in spite of effort. The roots of the plants by their hereditary qualities will allow certain salts to pass into the plant in certain proportions, regardless of the proportions of those salts in the soil. Corn and wheat growing side by side in the same soil have a very different composition, and use very different amounts of mineral salt and will stop growth at a particular season or when they have reached a certain size.

The productivity of an acre, therefore, depends in the first instance upon the character of the seed sown and the stock bred. What can be achieved further in this direction is entirely problematical. The story of selection of wheat by crossing different strains and so combining the desired qualities of various strains in a single one is romantic. As a result of a comparatively few years of experimenting the Marquis wheat was selected so that it became possible to grow that cereal over hundreds of thousands of acres in Canada which hitherto had not been available for this purpose on account of the short growing season and increased the yield nearly 30 per cent. The improvement of fruit trees and milk producers, fat producers, meat producers and egg producers in the past thirty years by the application of the Mendelian principles of heredity is well known to every one.

Of the external factors which influence the growth of plants the only ones which need to be considered at this time are water, nitrates, phosphates and potash. It is fully realized that these are not the only necessary substances for plant nutrition. Only recently the addition of sulfur as gypsum to the soil increased the yield of alfalfa fivefold, iron sulfate sprayed on the leaves of pineapples in Hawaii has made the fruit grow much more luxuriantly, and the addition of copper in very minute quantities has made certain peat lands most productive. But the only compounds which have to be added in any considerable quantity are the nitrates, potash and phosphates and on certain soils lime. An excess of one of these constituents can not compensate for a deficiency in another. If the soil is provided with an excess of fertilizer but lacks sufficient water the amount of growth is determined by the amount of water; or if there is an abundance of water and nitrates and potash but insufficient phosphate the amount of growth is limited by the amount of phosphate. The plants are not able to make substitutions for these substances as the manufacturer is frequently able to do when some one raw material is curtailed and his supplies of this are insufficient to permit of his usual production.

Another interesting relation between the amount of growth and the amount of materials in the soil used by the plants is that equal additions of the proper proportions of these substances do not yield correspondingly large amounts of plant substance. Each successive addition of a unit of fertilizer and water yields less and less until there is no further addition

to the yield. About one half of the amount of nutriment necessary to give the maximum yield of a certain type of plant will, as a matter of fact, give about 90 per cent. of the maximum. In other words, it takes as much fertilizer to add 10 per cent. to a 90 per cent. crop as it required to obtain a 90 per cent. crop. If the soil is not to be depleted, therefore, by the removal of crops which eventually find their way to the sea, it is necessary to keep the soil "filled" with nitrates, potash and phosphates, some 1,115 pounds of nitrogen, 441 pounds of potash and 267 pounds of phosphate to the acre. The nitrogen may be added by the fixation of atmospheric nitrogen by bacteria of several species, one of which forms nodules on the roots of the leguminous plants. It is this process of rotating crops with leguminous species introduced periodically which has maintained the nitrogen of the soil on many acres over long periods. There is a twofold necessity for water in the growth of plants. Not only does water make up a large part of the growing plant, but it also furnishes the means by which the salts are transported from the level of the roots to the leaves, where they are brought into relation with the sugars manufactured by the leaves and synthesized into proteins, the most individual and abundant constituents of the living substance itself. In general, it is found that in order to build up one pound of dry plant substance, some 300 pounds of water must be evaporated through the leaves. About 3,000 tons of water or fifteen inches over one acre is evaporated during the growing season of a good stand of corn. By proper conservation of moisture, however, some very remarkable yields have been achieved with much less rainfall than fifteen inches. In 1932 there is a record of wheat yield of forty-eight bushels to the acre on a farm in North Dakota, following a series of four dry years when the water table was much lowered and the rainfall during the growing season was only 6.63 inches. In 1927 in a wheat-growing contest in Czechoslovakia when there were only twenty inches of rainfall, 1,070 farms produced on an average forty-six bushels of wheat to the acre, and one of them harvested 87.2 bushels to the acre.

It has been ascertained experimentally by the successive additions of the various fertilizing substances until no further growth is made that the maximum yield of the most effective plants known to-day are able to utilize approximately 318 pounds of nitrogen per acre. The quantity of carbon is not apparently thus limited, for plants in which there is a low percentage of nitrogen are produced in larger quantity on a unit area than those in which there is a high percentage of nitrogen. The yield of 318 pounds of nitrogen per acre may be termed the per-ultimate yield. It is possible that other races of plants may be developed which are able to build up more nitrogen, but this is by no means certain. It must be borne in mind also that to obtain the per-ultimate yield requires the addition of twice the quantity of water and fertilizer necessary to produce 90 per cent. of this.

It is only rarely in practice naturally that water and fertilizer are supplied in the proper amounts to yield anything like a maximum crop. The expense is generally prohibitive, except for laboratory experiments. Experiments have been made in this country, however, under field conditions which have yielded in some cases crops as abundant as have ever been obtained in the open in any part of the world. But because of the practice of extensive rather than intensive cultivation, the average yield of the farms of the United States is only about 12 per cent. of the highest yield known.

In the midst of the last war when a shortage of the principal foodstuffs was

imminent, the U. S. Bureau of Plant Industry carried out a number of experiments on a large scale in order to determine to what extent the production of food might be increased most economically of man power and machinery. Some of the plots were only one acre in extent, but others were as much as eighty or one hundred acres. They were located in Washington, California, Colorado, Virginia, Kansas, etc. A comparison between the best yields of the six principal crops with the average for the years 1927–30 over the whole country and with the highest known yield in any part of the world is instructive (Table V).

TABLE V

| Crop | Average | Highest yield in the expt. | | Highest known |
|---|---|---|---|---|
| Wheat . | 14.4 bush. | 117 bush. | 8 × average | 122.5 bush. |
| Barley . | 24.1 | 122.5 | 5 | 122.5 |
| Oats ... | 30.4 | 183.7 | 6 | 245.7 |
| Rye ... | 12.8 | 54.4 | 4¼ | 54.4 |
| Potatoes .. | 114.9 | 790 | 7 | 1156 |
| Corn ... | 25.5 | 174 | 7 | 225 |

From the results of these experiments, and knowing the actual production of these crops in 1927–30, it is obvious that the same yield might have been obtained from the following acreages: wheat, 5.26 million, barley 2.29, oats 5.20, rye 0.87, potatoes 0.30, corn 9.16 and sugar beets 0.21, a total of 23.29 million acres. This is an area somewhat less than that of all the farms in the state of Colorado alone. But as no allowance has been made for accidents from insect plagues or plant diseases or vagaries of weather some margin of safety should be provided for. If 30 per cent. is allowed for these inroads, the acreage is increased to 33.2 millions of acres, which is less than the total area of all the farms in the state of Kansas. This increased intensity of agriculture would, naturally, bring about a great reduction in the number of farmers and a great deflation of farm values with correspondingly great social and economic repercussions. These figures, however, give some hint of what may be expected from the more general application of thoroughly scientific agricultural methods.

As indicated above, the production of starch and sugar is much greater than that of protein. Only about 15 per cent. of the protein molecule is nitrogen, so that the per-ultimate yield of 318 pounds of nitrogen per acre represents about 2,200 pounds of protein, while in a corn crop 2,200 pounds of protein is associated with over 9,300 pounds of carbohydrate in the seeds, stalks and leaves. An acre of potatoes yielding the maximum in the Bureau of Plant Industry experiment cited above, 790 bushels, produces 6,542 pounds of carbohydrate in the form of starch; the maximum yield of sugar from sugar cane is 20,000 pounds a year. The highest yield of protein obtained from the maximum corn crop in the experiment mentioned above is about 2,000 pounds, but less than 800 pounds are digestible because of the fact that it is largely surrounded by indigestible cell walls of cellulose. A maximum crop of onions, 40,000 pounds to the acre, contains 760 pounds of protein, and as will be apparent presently when we look into the requirements of a man for a year eating approximately the kinds of food which he is accustomed to in the United States and making due allowance for variety of food, the adequate supply of the vitamins, etc., the problem of providing protein becomes more difficult. It is necessary to provide an abundance of nitrogenous food for the domestic animals which furnish man with meat and milk and eggs. These are exceedingly important sources of the proteins which man consumes and, as will be seen later, require a large area for their production. There are several ways by which it is possible to increase the amount of pro-

tein produced by an acre. First, the growing period may be shortened so that several crops might be raised in place of one. This is hardly practicable, however, because it entails raising the plants in an artificially controlled illumination and artificial climate with high temperature during the winter months. It has only recently been discovered that the length of day has an important effect upon the maturing of a variety of plants. In one experiment reported in the Year Book of the Department of Agriculture for 1920, soybeans, which are an excellent fodder for cattle, were germinated on May 17 and kept in a dark greenhouse except for seven hours daily, when the plants were moved out of doors. These plants blossomed in 26 instead of 110 days, as did the controls. It is in this way possible to get the fruit in a much shorter time than normal and so telescope the successive crops, as it were.

A more practical device depends upon the fact that the absorption of nitrates and the building up of protein does not go on at a uniform rate during the entire life history of the plant. Much more than half of the nitrogen is taken up in the first half of the growth period. Later, while the carbohydrate is being increased and the plant may be increasing its dry weight considerably, the protein is simply shifted from one part to another. As the seeds ripen there is a great concentration of protein from the leaves in the seeds. We may not find the traditional menu of Nebuchadnezzar practical for ourselves, but by feeding to cattle the partly grown products of the soil it is possible to increase the potential yield of protein during one season several fold. Instead of reaping the golden grain it is more economical from the point of view of the production of protein to keep the grain fields closely cropped like a well-kept lawn, the clippings being cured and fed to the cattle. The use of ensilage by the dairy farmer is simply the practical application of this principle. In one experiment on a mid-western farm, wheat was planted during the second half of August and clipped from eighteen to thirty-one days later just before the stalks showed "jointing." On the best soil from 1,000 to 2,000 pounds of dry hay testing 30–40 per cent. protein were obtained from an acre. At this rate, the same planting may be clipped several times before freezing and again several times in the spring. On May 15 the wheat was plowed under and the field was planted in Sudan grass and yielded one ton of dry matter every ten days until wheat-planting time. The total yield for the year by this treatment was 7 tons of wheat and Sudan hay containing 4,000 pounds of protein per acre. Obviously this method of culture has great significance from the point of view of the dairy man and stock raiser, for the seven tons of hay, reckoning only 13 per cent. digestible protein and 66½ per cent. digestible carbohydrate, is the equivalent of 233 bushels of wheat or 250 bushels of corn, about five times the nutritive value of ordinary corn and wheat land cropped but once a year.

There is still one other way by which the yield of protein from an acre may be increased, although this may not be entirely practical with the present technical arrangements. The microscopical colorless plants like the yeasts are composed of protein to the extent of 50 per cent., which they synthesize from carbohydrates and nitrates or ammonium salts. By growing yeast in solutions of sugar to which nitrates are added a very rich protein food to supplement fodder is possible. In this way one pound of sugar may produce one half pound of yeast. Thus a pound of sugar may give rise to one fourth pound of protein in the form of yeast. In addition alcohol is produced, which has a high commercial value

for its own sake. There are strains of sugar-cane which have recently been bred which yield, according to Dr. William Crocker, of the Boyce Thompson Institute, fifteen tons of sugar to the acre or through the action of yeast three and three fourth tons of protein.

Allowing an annual consumption of eighty pounds of protein, this would furnish enough for ninety-three men. The growing period for the cane, however, is eighteen months rather than twelve months, so that the number of men which could live on this protein would have to be reduced to about sixty-two or 39,680 to the square mile. In addition to eighty pounds of protein, however, a man must consume sufficient non-nitrogenous food to yield 851,200 calories per year, for an ample energy requirement for a year is 1,000,000 calories, of which the eighty pounds of protein yield 148,800. The 851,200 calories might be obtained from 458 pounds of dry carbohydrate. The protein and energy requirements for the year would thus be obtained for one man on 0.039 acres or about twenty-five persons to the acre.

But this heavy yield of potential energy from an acre planted in sugar-cane with fifteen tons of sugar does not tell the whole story of what the sugar-cane actually builds up, for there is also a residue after the extraction of the sugar of 5.3 tons of cellulose. Twenty and three tenths tons of carbohydrate are therefore synthesized to the acre, in the growing cycle of 540 days or 75 pounds a day. This amount of plant tissue represents 139,500 calories. It has been calculated that on the 40th parallel of north latitude between May and October the solar energy reaching the earth is $30 \times 10^6$ calories, so that this plant is utilizing less than a third of 1 per cent. of the solar energy, not a highly efficient engine. The diet of yeast and sugar is, of course, a highly impractical sort of diet. While starvation might be avoided for a short time on this limited fare there would soon come a revulsion of appetite and serious digestive disturbances and nutritional disorders. The diet would lack flavor, variety and bulk and certain vitamins. The problem of adding artificial flavors, vitamins and bulk which would render the diet satisfactory for an indefinite period is by no means insuperable. It is noteworthy that a few years ago at the Cornell experiment station there were slaughtered two sheep which had been reared entirely upon artificial foods, casein, cellulose, starch, vitamins and salts, that is, on foods which had been concentrated and processed so that not a single blade of grass or kernel of corn had been eaten by these sheep, which were apparently in a perfectly healthy condition.

It may not be an ideal of life to reduce dining to the rigorous limitations indicated in this program. How many of us would submit to such a restriction of tickling of the palate is to be determined only by the psychologists. Possibly by proper conditioning from early childhood or infancy we might remain as healthy and happy as the sheep which were fed entirely on synthetic and processed foods. Incidentally, we consume a good deal of thoroughly artificial, processed food even to-day and prize it highly. Cane sugar, chocolate, cocoa, casein products, milk powders, gelatin, olive oil, corn oil, cotton seed oil, to say nothing of flour itself and the various bran preparations which are widely advertised and attractively packed in order to combat constipation, are all highly artificial foods to which most of us have become thoroughly accustomed and of which we are inordinately fond. Twenty-five persons supported on an acre of ground with a very small amount of laboratory or factory space for the synthesis

of the accessories of the diet may not be so far distant a dream, after all.

In order to remove this discussion from the realm of the theoretical but by no means impossible, let us look at this matter of human diet from the point of view of our more normal food habits. As already indicated, eighty pounds of protein a year and approximately one million calories are needed by an average person not engaged in hard labor. About one half the calories should come from the so-called "protective" foods, milk and dairy products, vegetables with their salts and vitamins, fruits, eggs and meat. The different proteins which may be isolated from the naturally occurring foods vary greatly in their ability to promote growth and supply the wear and tear of the adult body. It is for this reason that a variety of foods becomes a practical necessity, unless the kind of protein is very carefully selected. Fats of certain kinds have to be supplied, not only to regulate the digestive processes which are adapted to a certain amount of fat, but also to supply certain of the vitamins which occur only in association with them.

Those of us who do not give a great deal of thought to our diet and who eat what is set before us and take it all in the round of daily activities to eat three times a day, may not have a very clear idea of just what we consume in the way of foods purchased and grown on the farm. Some months ago there was published in Circular 296 of the U. S. Department of Agriculture a liberal diet which was supposed to furnish an abundance of the varieties of protein and the vitamins necessary for the maintenance of health for one man for a year. It calls for 1,874 pounds of food, including 77.6 pounds of protein and has a calorific value of 1,054,000 calories or 3.4 ounces of protein and 3,000 calories a day (Table VI).

TABLE VI
YEAR'S FOOD FOR ONE MAN

| Foodstuff | Pounds | Pounds protein | Calories |
|---|---|---|---|
| Cereals | 100 | 13.8 | 167,500 |
| Milk | 700 | 23 | 227,500 |
| Potatoes | 129 | 2.3 | 40,000 |
| Root vegetables | 46 | 6 | 15,750 |
| Beans, corn, etc. | 33 | 1.58 | 16,000 |
| Leafy vegetables | 142 | 2.89 | 15,340 |
| Tomatoes and citrous fruits | 110 | .99 | 12,130 |
| Fruits | 292 | 1.67 | 69,405 |
| Butter | 35 | .35 | 126,000 |
| Lard and other fats | 15 | .00 | 62,650 |
| Sugar | 45 | .00 | 83.600 |
| Molasses | 15 | .36 | 19,370 |
| Meat | 149 | 22.39 | 164,540 |
| Eggs | 45 | 5.35 | 28,575 |
| Fowl | 18 | 2.3 | 5,310 |
| Total | **1874** | **77.59** | **1,053,625** |

That this is a liberal diet is borne out by the extensive experiments carried out by Atwater in Wesleyan University. For example, he found a group of Japanese students consumed each sixty-seven pounds of proteins in a year and 855,195 calories. A German physician consumed 90.4 pounds of protein for the year and 1,008,130 calories; American college students at student boarding houses consumed only seventy-two pounds of protein and 1,250,000 calories.

The calculation of the areas upon which these various foods may be grown is very simple mathematically, although the obtaining of the necessary data is rather difficult.

Let us consider the area necessary to produce the dairy products and meat. Figures from the book of E. H. Starling, "Feeding the Nations" (p. 85) show that in German agriculture before the war one acre was sufficient for the production of 560 pounds of milk so that the 700 pounds could be produced on 1.26 acres. On the basis of twelve pounds of cattle feed for the production of one pound of meat or milk and assuming the maximum production of feed of the experiments of the Bureau of Plant Industry referred to above, the same area is required.

Butter is one of the most expensive

foods but one which is quite important in the well-balanced diet. As one pound of butter is 85 per cent. fat and average milk contains 4 per cent. fat, it requires about 21.25 pounds of milk to make a pound of butter and 255 pounds of dry fodder to yield 1 pound of butter. To produce thirty-five pounds of butter therefore requires 8,925 pounds of feed. If the fodder has the richness of corn this can be raised on about .83 acres. The rest of the fats may be reckoned as by-products of the pork and other meats which are consumed and so would not require additional acreage to produce. The hen is not quite as economical a producer of human food as are the cattle. Probably the higher body temperature and the smaller size of the fowl with a relatively large surface cause more of the food to be consumed at the same time that a unit of growth or food products is being made. It takes about fourteen pounds of chicken feed to make a pound of eggs. For the sake of simplicity, if we reckon upon the use of wheat as the food of the hens, 630 pounds of wheat must be raised to produce the forty-five pounds of eggs; 0.11 acres will suffice for this. The eighteen pounds of poultry included in the diet requires an additional .045 acres.

One hundred and forty-nine pounds of meat, if it is that of young animals, are produced at an expenditure of 1,788 pounds of dry fodder. The flesh of steers costs much more in the way of fodder to produce, for after growth is attained the animal continues to feed without further increase in weight. If this fodder is represented by corn and corn stalks produced at the maximum American rate of 174 bushels to the acre, it can be produced on 0.09 acres.

The 100 pounds of cereal grains eaten in the year may be regarded as 5,850 pounds of wheat and may be had from an acre which has yielded 117 bushels; this requires only 0.017 acres. The 129 pounds of potatoes can be raised on an area of 0.003 acres, since the highest yields are 790 bushels or 47,400 pounds.

It is more difficult to arrive at an estimate of the area necessary to supply the 292 pounds of fruit called for in the diet. According to figures obtained from the Bureau of Agricultural Economics of the U. S. Department of Agriculture a good yield of apples under favorable conditions is 36,000 pounds per acre, so that the 292 pounds of fruit might be obtained from .008 acres.

Vegetables, which make up about one fifth of the diet in actual weight, may, for the sake of simplicity, be considered as made up entirely of tomatoes, which have a composition which is not far from the average of the more common vegetables, yielding 100 calories per pound. As 40,000 pounds of tomatoes have been raised on an acre in the United States, the 331 pounds consumed by a man in a year could be grown on 0.0083 acres.

Forty-five pounds of sugar and fifteen pounds of molasses may be obtained from either sugar-cane or sugar-beets. The former is more productive but can not be grown where there is danger of frost, so for the sake of making the self-sustaining farm in the latitude of the United States we shall obtain the sugar from beets. Sugar-beets containing 15 per cent. sugar may be grown to the extent of 42 tons to the acre. Although the molasses is a by-product from the crystallization of the sugar, for the sake of simplicity it may be added to the sugar as if it required additional acreage to produce. The sixty pounds of sugar could be grown on 0.0005 acres.

Combining the areas required for the different items of the diet, we find that a total of a little less than 2.4 acres is necessary for the support of one man for a year if the highest yields known in the

United States are obtained. Although the idea may be advanced that this does not allow sufficient margin of safety and that the figure is therefore misleading, it may be replied that the large area required for dairy products—2.09 acres—is obtained on the estimate that it requires twelve pounds of fodder to produce one pound of milk. This is simply an average and does not represent the maximum yields of selected herds. As a matter of fact the best milk and fat producers as a result of selection can produce about double the quantity of milk and fat so that the dairy products would require only half the area allowed in the above calculation and the entire acreage would then come to one and a third acres. So, too, the best swine gain one pound for every three pounds of food eaten, and as the dressed pork with the lard is approximately 60 per cent. of the live weight, it would take only five pounds of fodder to produce one pound of human food.

The social and economic consequences of this shrinkage of farm land are extremely far reaching. Part of the present plight of the farmer whose skill is insufficient to achieve the best results and whose products can not be economically distributed is tied up with the increasing efficiency of farms and the increasing capacity of man to produce food from the ground.

The displacement of the draught animals by the tractor has not only made unnecessary the product of 30 million acres of farm land formerly needed for energizing farm animals but has made it possible for one man to cultivate a vastly larger farm. As gasoline and oil reserves are drained more and more, the farmer may be called upon to devote more of his energy to raising sugar or other crops from which a fuel like alcohol may be obtained to run his tractors, which will be renewed year after year by the grace of the sun. Before the farm land has shrunken to the extent that has been indicated in the reduction of farm area necessary to feed a man, it seems highly probable that the cellulose of plants will be used more and more in the arts to take the place of building materials, plastics, etc., so that the farmer may be called upon to grow new crops which yield materials that will not be used for food. It seems very evident that because of the technical advance of agriculture the farm must become more of a large-scale productive unit in which a degree of efficiency comparable to that of well-managed manufacturing plants will be the aim.

# COMMENTS ON CURRENT SCIENCE

By SCIENCE SERVICE[1]

WASHINGTON, D. C.

## BEGINNING OF ENGLAND'S GREAT SCIENCE BODY

On these cooler fall days, when the man of the family trudges down the cellar to start the furnace, it is an interesting speculation to turn back time some three centuries and consider what might have been the fate of science if the homes of that day had had good heating plants that would have made houses cheery places in which to stay evenings.

As it was in the 1640's, private homes were, for the most part, poorly built, uncomfortable and cold. In contrast the taverns were the places of warmth and cheer. Thus in the snappy fall of 1645 it is not strange that a group of diners should meet regularly at the Bullhead Inn in Cheapside, London, to discuss and experiment in natural philosophy.

As Professor C. S. Slichter, of the University of Wisconsin, recently told the Mathematical Association of America, it was this group—called by Boyle the "Invisible College"—that in 1660 organized the "Visible College," which within two years became the Royal Society of London for the Improvement of Natural Knowledge.

Universities and colleges there were in the England of that time, but science got its British start through the Royal Society and not through Oxford or Cambridge, where Aristotle and the seven philosophies were safely, and all too contentedly, entrenched.

No hide-bound, long-bearded academicians were the new Royal Society members. Among the founders was a chemist, a physicist, a bishop, two peers and so on. Robert Boyle, Robert Hooke and Christopher Wren were names on the original roster. It published Sir Isaac Newton's famed "Principia." On the title page can be found "Samuel Pepys, President Royal Society, he printed it."

Yes, the versatile Samuel Pepys was indeed president of the Royal Society in 1684. This shows the Royal Society's broad membership whose charter—granted on July 15, 1662, by royal decree—is considered one of the greatest events in British history.

## FEDERAL SURVEY OF SCIENCE RESOURCES

The science resources of the nation are coming under the scrutiny of a group of experts rallied by the National Resources Committee, just as other authorities have conducted inquiries into technological trends, population, minerals, production and consumption, land, water and public works.

Here we have working for the nation a "brain trust" worthy of the name, not only because its members are competent producers of arranged facts and ideas, but because they are engaged in blueprinting what may be our future.

The planners viewing our science resources work under a committee of nine, appointed three each by the National Academy of Sciences, the American Council of Education and the Social Science Research Council. Thus boundaries between the physical and natural sciences, the social sciences and education, which are man-made but nevertheless real, are in part erased.

A study of "federal relations to research" is being conducted on behalf of the Science Committee by a small staff directed by Dr. Stuart A. Rice, chairman of the U. S. Central Statistical Board. The inquiries and practical results of the now-extinct Science Advisory Board of 1933 vintage will be remembered. There is more accent on the social consequences in the present inquiries

[1] Watson Davis, director, Frank Thone, Robert D. Potter, Jane Stafford, Emily C. Davis and Marjorie Van de Water, staff writers.

and less consideration of the "pure" research so disdainful and yet so fruitful of our industrial revolutions.

The technological trends report of some months ago emphasized the extraordinary ability of the American people to invent new ways of doing things and to adopt mass production methods for putting new inventions into use. Soon to appear is a National Resources Committee report on population problems, directed by Dr. Frank Lorimer. It will consider whether we are conserving our human resources, how many people this land will have in 20, 50 or 100 years and what kind of people.

### NEW TOOL FOR BIOLOGICAL RESEARCH

Scientists are just beginning to talk about it, but there is good reason to believe that one of these days the science of biology will be supplied with a new tool of discovery by its sister science of physics. The tool would be the bombarding of biological specimens with streams of swift-flying electrons and the observation of the pattern created by the electrons as they bounce back.

This technique—known technically as electron diffraction—has already been used by the physicists to study the crystal structure at the surface of metals and other solid crystals. To Drs. L. H. Germer and C. J. Davisson, of the Bell Telephone Laboratories, go the credit for the initial experiment in 1927.

Virtue of the electron diffraction method is that it permits studies on very thin films, which may be only a single molecule thick. Such films have importance in biology. While the diffraction of x-rays allows scientists to study large chunks of matter, the x-ray method falls down completely for very thin films of molecular thickness. And it is just at this point that the method of electron diffraction steps in and carries the burden.

The technical difficulties of using this possible new tool are mainly two; the difficulty of interpreting the results for the complex things which are commonplace in biology but rare in physics, and the difficulty of mounting the biological samples in the necessary apparatus. On this last point the trouble is that all operations must be carried out in a vacuum, and there is always the question of whether biological material remains unchanged in a vacuum.

It has been suggested that the biological samples might be frozen at liquid air temperatures and quickly inserted in the apparatus, but this presents additional complications which are typical of the difficulties that must be overcome.

### MARS AN ARID PLANET

It was once the fashion to suggest that the ever-curious marks on the planet Mars were due to some human-like agency; a race of Martian men who had constructed gigantic ditches or canals. Then when the markings were found to change with the Martian seasons the hypothesis was brought forward that the markings were, perhaps, plant growth and other vegetation.

But even this last suggestion that the canals on Mars were merely great straight stretches of plant growth (possibly like the Mid-western shelter belt may be a century hence) has had its difficulties.

One of the most recent of these troubles comes from the great Mt. Wilson Observatory of the Carnegie Institution of Washington, where it has been found, from a study of the light spectrum of Mars, that the ruddy planet has little, if any, water vapor present in its atmosphere, at least in the equatorial region where the observations were made. An outside limit for water vapor in Mars' air would be about 5 per cent. of that present in the earth's atmosphere.

The first months of 1937 saw the planet Mars come to one of its nearer approaches to the earth. Astronomers at Mt. Wilson decided to use the great 100-inch diameter telescope and special photographic plates to test, again, the

question of the presence of water vapor on Mars. Director Walter S. Adams and Dr. Theodore Dunham, Jr., slowly turned the huge telescope in the direction of the earth's companion planet and for six hours allowed the faint light to strike their photographic plates.

Unfortunately for the plant growth hypothesis of the origin of Mars' canals, little if any water vapor was found. The possible way out of the dilemma, however, would be to have the Martian plants consist of some form of cactus that needs but little water and could live in the arid region corresponding to Mars' equator.

### BRAIN WAVES HAVE AN UNKNOWN DESTINATION

The human brain is constantly beating out a rhythm of brain waves. In its own unrecorded code, the seat of man's intelligence is tirelessly sending signals.

Where do they go? What happens to them? That is the question raised by modern psychological research. The brain used to be thought of as a sort of telephone exchange where messages sent in from the body's outposts, the eyes, ears, mouth, nose and fingers, are connected with the muscles they direct. Now it is known that the brain is more than a message center. It is also a reservoir of energy—a starting point for spontaneous activity.

The brain waves are the electrical accompaniments of this physiological activity, having its first beginnings in the brain itself. But we are used to thinking of electrical impulses as traveling. Signals are not only sent out but usually also received. Messages have a destination as well as a point of origin. What is the destination of the brain's messages? No one knows.

Tests were recently made at the University of Iowa to find out whether they travel to the outer limits of the nervous system. Similar electrical rhythms had been observed in the finger-tips. It occurred to the Iowa scientists that this might be a reverberation of the brain waves. Under the direction of Drs. Lee Edward Travis and Charles N. Cofer tests were made.

Although the frequencies of the finger-tip waves are practically the same as those of the brain waves, the patterns do not correspond. Some of the subjects had large and regular, while others had small and irregular brain waves. The finger-tip waves do not follow the brain waves in this respect. The brain waves might be interrupted or change without any corresponding change in the finger-tip rhythm. They are not the same. The secret of the brain wave destination remains unsolved.

### ANIMALS OF COOLER REGIONS LARGER THAN WARM-LAND KIN

Science now provides support for the common observation that races living on mountain heights or in northern latitudes are on the whole larger than those living at low levels and farther south. This opinion, usually held only as regards human beings, is extended to include animals as remote from man as birds and insects, in studies made by Professor Theodosius Dobzhansky, of the California Institute of Technology.

Professor Dobzhansky bases his conclusions both on studies of specimens collected in the field and on the growth of a number of different kinds of organisms in the laboratory.

Races of mammals inhabiting cooler regions, although they may be in general larger, have shorter body appendages (tails, legs, ears) than races of the same species from warmer regions. Among birds the same is true for the relative lengths of beak, legs and wings. Races of mammals and birds and some invertebrates living in cooler climates are larger in body size than races of the same species in warmer climates. In mountain countries races from higher elevations are larger than those from the lower ones.

Professor Dobzhansky also exposed pupating butterflies from Central Europe

to both cold and heat. The heated pupae developed into butterflies resembling those of the same species found in Syria and other Mediterranean areas; the chilled ones produced insects more like those of northern Scandinavia.

The experimenter points out a possible physiological usefulness in these phenomena. In cold countries short ears, legs and tails are an advantage because they radiate less heat; in warm countries such economy is not so imperative. The larger body size, on the other hand, is correlated with a relatively smaller body surface—again effecting an energy economy.

### DEER, LIKE HUMAN BEINGS, THRIVE ON VARIED DIET

Deer, like ourselves, seem to thrive best when they get a variety of things to eat. Again like ourselves, they face the problem of possibly harmful monotony in diet most acutely in winter, when the supply of "greens" offered by the woodlands is at its lowest.

In an effort to learn the absolute minimum on which deer can survive in winter, L. A. Davenport, of the Michigan Department of Conservation, kept a considerable number of the animals in separate feeding pens last winter. His control group received "browse" of varied types—abundance of white cedar and other evergreens and plenty of bud-bearing twigs of broadleaved trees like oak and maple. Deer in the other pens got only one kind of browse for each experimental group. One group received only white cedar, another oak, another maple, and so on.

The animals on a single-ration diet fared poorly. They all lost weight, and some of them died. The control group given the mixed diet, on the contrary, throve as well as they would have in the open woods.

Mr. Davenport's experiments show the great importance of white cedar or arbor vitae as winter browse for deer, at least in this part of the country. The deer having free choice of diet made white cedar about 80 or 85 per cent. of their total feeding, and the rest a mixture of hardwood buds. And the group fed on white cedar and nothing else got along decidedly better than any of the other deer kept on the other "monotony rations."

It would appear therefore that, at least for deer of the Michigan type of forest, white cedar is winter "meat and potatoes," while other browse is "salad."

### NUTRITION, VITAMINS AND NOBEL PRIZE AWARDS

Two Nobel prizes, one in chemistry and one in physiology and medicine, were awarded this year for research closely related to nutrition and particularly for vitamin studies. Few of the Nobel awards have been made in this field.

The first time the Nobel prize committee recognized any of the scientific work on problems of human nutrition was in 1928, when Dr. Adolf Windaus, of Göttingen, Germany, received the chemistry award for his part in research showing that ultra-violet light, either in sunlight or artificially produced, will activate the chemical, ergosterol, and confer on it rickets-preventing or curative properties. The large number of substances now irradiated to make them potent sources of the antirachitic vitamin D resulted from such research.

Even more fundamental vitamin research won the 1929 award in medicine for Professor Christian Eijkman, University of Utrecht, Holland, and Sir Frederick Gowland Hopkins, University of Cambridge, England. Professor Eijkman was the first man to produce experimentally a disease of dietary origin. As a result of his work, lack of vitamin B was shown to be the cause of beri-beri, serious nerve disease. Professor Hopkins was first to show that animals, including man, can not live, grow and reproduce on a diet of fats, proteins and carbohydrates alone. The extra vital substances we now know as the vitamins.

This year the chemistry award was shared by Professor Paul Karrer, University of Zurich, Switzerland, and Professor W. N. Haworth, Birmingham University, England. The award in physiology and medicine went to Professor Albert von Szent-Györgyi, Francis Joseph University, Hungary. The first two investigated the complex chemical composition of vitamins A, B and C. Professor Karrer worked out the formulas for vitamins A and $B_2$. Professor Haworth and Professor Szent-Györgyi studied the anti-scorbutic vitamin C.

### TWO NEW TREATMENTS AND TWO NEW DANGERS

Two new and spectacularly successful methods of treating disease have recently come upon the scene. With them, unfortunately, have also come two new dangers to health and life. The two new treatments are insulin shock for one widespread mental disease, and sulfanilamide for a growing number of infections or germ diseases. The danger is in the misuse or careless use of these new treatments.

The deaths of more than 80 persons who took a so-called elixir of sulfanilamide, which contained a poison besides the curative drug, has tragically emphasized the danger inherent in this and other new potent remedies. There is no guarantee that another similar tragedy will not occur. The elixir deaths occurred because the manufacturer and his chemist did not take the trouble to learn, either by consulting scientific literature or by making animal tests, the effect of diethylene glycol on the body. They simply found it would dissolve enough sulfanilamide so that two teaspoonfuls would contain a useful dose of the latter chemical.

Diethylene glycol, presumably, will not be used again in such a remedy. But physicians predict that manufacturers will market other sulfanilamide remedies which they will claim are better than the original sulfanilamide itself. These may or may not be dangerous, may or may not be better than sulfanilamide. Unless carefully tested on animals, their potential danger will remain unknown until the elixir tragedy is, perhaps, repeated.

The danger to life in insulin shock treatment can only be averted by constant watchfulness of the physician. "Constant" here means watching the patient every minute, literally, until he has recovered from the shock. This hazardous treatment can be given safely only in a hospital. Yet there have already been reports of its being given in the patient's home with near-tragic results.

### THE PLAGUE OF MALNUTRITION

"When do we eat enough and properly?" That is one of the world's major questions to-day. There is no major famine plaguing mankind to-day, but the specter of hidden hunger is abroad in the world.

Millions of people in all countries are suffering from malnutrition. That means, not getting enough of the right kind of foot to eat. It means little children who are unnecessarily sick, boys and girls with bad teeth, people who lack energy to do more than merely exist.

The magnitude of the problem is emphasized by a report of a committee of the League of Nations that has had the aid of experts from many countries during the past two years. The surprising thing about this condition is that, as the League committee notes, it can exist in a world in which agricultural resources are so abundant and agriculture is so perfected that supply frequently outstrips effective demand. Quite evidently it is a problem for the statesman and international cooperation rather than merely a concern of the farmer, the food merchant and the housewife.

Improved nutrition means more use of what the dietitians call "protective" foodstuffs, such things as milk and vegetables. Because these are perishable they must be produced near where they are eaten. That means diversified local farm-

ing. But there are larger potential markets for the corn and wheat growers, too, because not every one has enough of these energy-producing foods. How to fight the hidden hunger plague: Tell the people about the right kinds of food to eat. Lower the cost of food. Let governments see to it that their populations are fed adequately, even though this means direct grants. The league committee is confident that in the long run such a program with a low relative cost would save incalculable suffering and economic loss.

### SUBMARGINAL FARM AREAS CONTAIN "IMMOBILE" PEOPLE

Any plan for a wiser use of America's lands, retirement of submarginal regions, resettlement of the people, must take into consideration the human angles. Helpful in this connection is a study by the U. S. Department of Agriculture of a county in Kentucky, typical of the unprofitable farming region of the southern Appalachians. In Knott County, the ridges are narrow and the slopes are steep. Homes are small, one-story houses, unpainted or shabbily painted, with interior walls often covered with newspaper and worth an average of $343. Modern conveniences are lacking, food scarce. But many have flower gardens.

The average money income from a farm in Knott County is just $56 for each family each year. Knott County has poor roads, poor schools, limited sanitary and medical facilities. But the inhabitants of Knott County are what the experts of the U. S. Department of Agriculture call "immobile." They like Knott County. They have always lived in Knott County. In Knott County they hope to die.

Of the grown sons of the families interviewed, over 73 per cent. were still in Knott County. Less than 20 per cent. of the men and only six per cent. of the homemakers had ever been in all their lives beyond Kentucky or some adjoining state. Some of the men had been away to war. Some had gone looking for work. One girl had been on a honeymoon. Three had gone to funerals. Those who had lived away from Knott County had come back because they were homesick or because they "couldn't do no good" away from home.

In this modern day of loose home ties, wandering youth, drifting childless families, trailer residence and transient camps, population experts, psychologists and sociologists urge attention to this "immobility" of the Kentucky people before plans are made to move them from their submarginal acres.

### BLOND COMMUNITIES IN NORTH GERMANY

Tallest blond communities in the world is the distinction claimed for three isolated villages in a marshland near Bremen. Nevertheless, they are not classified as pure Nordics by Dr. Christian von Krogh, of the Munich Anthropological Museum, who has just completed a special study of them. He calls them "Nordi-Falians"—by analogy perhaps with the tall, medium-blond, but rather round-headed Westphalians.

This group of people are landholding peasants, and they have held the same land for centuries. Two of the villages, Arsten and Habenhausen, have been in existence since prehistoric times; the third is comparatively new, having been founded in the eleventh century on land that had just been drained. Its name, Neuenland, englishes as "Newland."

The farmer families marry only among themselves, keeping the landless workingmen of the towns excluded from their family circles. A considerable degree of inbreeding has naturally resulted. Tracing family trees back four generations, Dr. von Krogh found only 69.4 per cent. as many ancestors as there would have been had no intermarrying occurred.

That inbreeding to this degree has not harmed the stock physically is evidenced by the condition of the people to-day. The average body height is five feet nine inches; it is the greatest group height known in Europe. The people have big

heads—high, long, and wide—with large faces to match.

Gentlemen of the community just about have to prefer blondes, unless they prefer to remain bachelors. Prevailing hair color is dusky blond, and over four fifths of the population have blue eyes.

## NEW INDUSTRIAL JOBS FOR WOOD

Wood is just plain lumber, a building material, to most people, although they have heard that both the paper upon which newspapers are printed and rayon underthings are made from wood. Utilization of wood has many ramifications in modern industry to-day. But the editors of *Chemical and Metallurgical Engineering* in a survey discover that wood and its products will have many more uses in industry's to-morrow.

Take the troublesome liquids that result from the sulfite pulping process, first step toward newsprint and rayon. Sulfite waste liquor contains lignin, partner to cellulose in wood. Chemists are looking for jobs for lignin, confident that eventually it will be found to be as talented chemically and industrially as cellulose. In the state of Washington the sulfite liquor is used instead of oil for dressing the dirt roads, stabilizing the soil and giving a hard, dust-free crust. There is also research looking towards its use as fertilizer.

In Europe wood-working plants make gas from wood waste for power purposes and automobiles are fueled by wood-producer gas, made as you ride, with 25 pounds of wood the reported equivalent of a gallon of gasoline. Germany makes sugar and alcohol from wood by two different processes, but it is concluded that this would not be done profitably in the United States.

Then it is possible to squeeze ground sawdust and mill waste into hard dense products that are stronger than the wood that nature made. Inferior softwood lumber can be pressed into hard, dense attractive "hardwoods" and the lumber industry is looking into the commercial possibilities of this transformation.

Awake to the fact that they are not limited to the form of wood as produced by the tree, useful as that is, lumber companies are installing their own research staffs and scientists are now helping lumberjacks and millhands in one of the oldest of American industries.

## DIESEL ENGINES

Few people have ever heard of the *Selandia* that twice yearly makes a round trip voyage of 22,000 miles to Bangkok in the distant Orient. For 25 years the *Selandia* has been plowing her way through the oceans and in 55 round trips has piled up mileage whose total distance is equivalent to three trips around the moon. The only noteworthy delay in all those years has been 10 days in port.

"Well, what about it," you ask. Only that the *Selandia* is the first Diesel powered motorship ever put into oceanic service and is the pioneer of the many newer vessels that have displaced steam in marine navigation. Ocean Diesel power is this year celebrating its silver jubilee.

That marine Diesel plants have traveled as far, figuratively, as the *Selandia* has in reality, is shown by the present total world's motor tonnage—11,900,000 gross tons. But even more important, Diesel power for a small motorship like the historic *Selandia* could now be fitted into a far smaller engine room, would weigh 30 per cent. less, yield 44 per cent. more power and drive the vessel at a speed 32 per cent. greater than does the *Selandia's* 1912 engines.

What another 25 years will bring forth in improvement is, of course, uncertain. But this much is certain. Diesel engines in ships have revitalized the development of marine transportation just as land transportation on the railroads is now undergoing a somewhat similar spurt for the same reason. The advantages of superiority swaying back and forth between competitors mark progress and make the wheels go round; peaceful revolutions, if you wish to call them that.

# THE TRANSMUTATION OF HEAVY ELEMENTS[1]

By the late LORD RUTHERFORD OF NELSON

DURING the past few years our knowledge of the transmutation of the elements by artificial methods has grown with great rapidity, and practically all the known elements have been found capable of transmutation on a small scale when bombarded by fast particles of suitable type. By means of an ingenious apparatus called the cyclotron, Lawrence has been able to produce copious streams of protons and deuterons with energies as high as 6 million volts and moving with velocities even greater than the $\alpha$-particles from radioactive substances. Such swift deuterons are capable of producing transformations even in heavy elements like platinum and bismuth. There is some evidence that the deuteron is broken up into its constituent proton and neutron in the intense field which exists close to a nucleus. The neutron may then be captured by the nucleus while the proton escapes. For example, four radioactive elements are produced from platinum, two of which have the same chemical properties as platinum, and are thus new unstable isotopes of that element, while the other two behave like isotopes of iridium. The interpretation of the results is complicated by the number of known isotopes of platinum, *viz.*, masses 192, 194, 195, 196 and 198. One of the radioactive isotopes of platinum breaks up with the emission of a negative electron and the other—an unusual event for heavy elements—breaks up with the emission of a positive electron. In the first case the isotope of mass 196 is believed to be involved; by the capture of a neutron a radioactive isotope of mass 197 is formed and this is transmuted by the emission of a negative electron into gold (mass 193). In the other case the isotope of platinum 192 forms a radioactive isotope 193, which by the emission of a positron forms a stable isotope of iridium (mass 193). One of the radioactive iridium isotopes is believed to be formed from platinum 196 by the capture of a deuteron and the emission of an $\alpha$-particle.

The radioactive isotope of iridium of mass 194 is then transformed into the platinum isotope 194 by the emission of a negative electron. The origin of the other iridium isotopes has not yet been settled.

The bombardment of bismuth by fast deuterons is of particular interest, as it leads to the production of a radioactive isotope of that element identical in radioactive and chemical properties with the natural radioactive body, radium E. This important result has been confirmed by showing that this artificially produced radium E gives rise to polonium—the first of the radioactive elements separated by Mme. Curie in 1897 from uranium minerals.

In general, the neutron is extraordinarily effective in producing transformations in the majority of the elements. In a number of cases very slow neutrons are far more efficient in this respect than fast ones. A suitable source of neutrons for such experiments can be obtained by bombarding beryllium with $\alpha$-particles from radium. The fast neutrons can be slowed down by allowing them to pass through material containing hydrogen, for example, water or paraffin. In this way more than 80 new radioactive isotopes have been discovered, most of which break up with the emission of $\beta$-particles. The action of neutrons on the heaviest known element, uranium, has been the subject of close study by Hahn and Meitner during the past two

[1] Abstract of a lecture given before the Royal Institution of Great Britain, on March 19, 1937.

years. Work with this element presents special difficulties on account of its spontaneous radioactivity. Nine new and distinctive radioactive bodies have been observed when uranium is bombarded by slow or fast neutrons. All these break up with the emission of β-particles and with half-periods of decay varying from 8 seconds to 3 days. It may well be that other radioactive elements of still longer life will yet be observed. Hahn and Meitner have conclusively shown that not only are three new radioactive isotopes of uranium formed, but also radioactive elements of higher atomic number than uranium. By the application of suitable chemical methods it has been found that two of the radioactive bodies have the chemical properties to be expected for eka-rhenium atomic number 93, two for eka-osmium atomic number 94, and one for eka-iridium and for eka-platinum atomic numbers 95 and 96, respectively.

It has been found that the new radioelement formed from uranium breaks up in a series of successive stages analogous in many respects to the well-known sequence of changes which occur spontaneously in uranium and thorium. The results indicate that three new radioactive series are formed, two of which probably arise from the main isotope of uranium (mass 238) after the capture of a neutron, and the third may be due to a less abundant isotope of uranium (mass 235). The two main series of transformations are believed to be isomeric and to be the consequence of two distinct varieties of transformation of the same nucleus which is formed from uranium 238 by the capture of a neutron. The possibility of such an isomeric change had been suggested some time ago in order to account for the fact that uranium X appeared to give rise to two distinct β-ray products. All the new radioactive bodies formed from uranium break up with the emission of β-particles. The active uranium isotope of half-period 8 seconds formed by the capture of a neutron is transformed successively into eka-rhenium of period 2.2 minutes, eka-osmium period 59 minutes, eka-iridium period 3 days, and eka-platinum period 2.5 days. The latter presumably forms eka-gold, but no certain evidence of transformation has been observed beyond this stage. All these elements have nearly the same mass, 239, but, owing to the liberation of energy in the form of a β-particle, the mass of each successive element in the series must slightly decrease. With the exception of the uranium isotope of period 23 minutes, all these transmutations are produced both by fast and by slow neutrons. On the other hand, the 23-minute body can only be produced by slow neutrons of a definite energy and not by fast neutrons at all. This effect is a typical example of what is known as a resonance phenomena of which we have many instances in other elements. The effective neutrons are strongly absorbed by uranium, and Hahn and Meitner estimate their energy to correspond to $25 \pm 10$ electron volts. From the recent work of Dempster it is known that uranium consists of three isotopes of masses 238, 235, 234. The abundance of these three isotopes is of the order of 100, 0.3 and 0.07, respectively. It may be that the 23-minute body arises from the capture of a neutron by the isotope of mass 235. It does not appear that the bombardment of uranium by neutrons has any affect in accelerating the natural disintegration of this element. A complex series of transformations also arises when the second heaviest element, thorium, is bombarded by neutrons. Radioactive isotopes of radium, protoactinium and actinium are produced, but the exact nature of the transformations involved are still under investigation.

In the course of the lecture, the formation of α-ray tracks was illustrated by means of a specially constructed expansion chamber. By special arrangements

an image of the interior of the expansion chamber was thrown on a screen by means of the light from an arc lamp. At the moment of expansion the tracks of $\alpha$-particles radiating from a source of polonium in the middle of the chamber were made clearly visible to the whole audience. The apparatus for this purpose was kindly prepared by Dr. E. Bretscher, of the Cavendish Laboratory. Experiments were also shown to illustrate the formation of radioactive bodies by exposure to slow neutrons, the elements indium and silver being used for this purpose. The marked $\beta$-ray activity produced in these elements and their rapid decay was shown by using a Geiger $\beta$-ray counter connected with a loud speaker. A preparation of uranium freed from uranium X was exposed to a source of neutrons, and the large increase of $\beta$-ray activity as a result of a few minutes' exposure was illustrated in the same way.

# ELECTRON DIFFRACTION AND SURFACE STRUCTURE[1]

By Dr. G. I. FINCH

PROFESSOR OF APPLIED PHYSICAL CHEMISTRY, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, LONDON

THE properties of waves are very different from those of bodies in motion. For example, though two waves can pile up together on meeting under favorable circumstances, they can also extinguish each other, and this is something which it is difficult to conceive of ever happening to two colloiding projectiles. Newton thought that light consisted of particles in swift motion, but when Fresnel and Young proved that light behaved like waves, Newton's corpuscular theory was abandoned. Soon after the war, however, it was found that light sometimes really did behave like a stream of particles and must therefore also be corpuscular in nature.

It seemed quite impossible to understand this duality in behavior until de Broglie, with a typically Gallic flash of genius, boldly postulated that all particles were guided in their motion through matter by attendant wave systems. When moving through empty space the particles in their behavior would show no signs of wave properties, but should do so when they came into contact with other particles. De Broglie calculated that the wave-length of the waves he believed to be associated with moving particles should be inversely proportional to their mass and speed, and would therefore be difficult to detect, except in the case of particles of exceedingly small mass, because otherwise the waves would be too short to be diffracted even by natural crystals, which are the finest gratings available. But electrons are more than 1,800 times lighter than the hydrogen atom, so that the length of the de Broglie waves associated with a stream of electrons moving at, say, 50,000 miles per second should be of the same order as in x-rays and therefore detectable by diffraction by crystalline matter.

The first experimental proof of the existence of de Broglie's moving-particle waves was carried out simultaneously and independently by Davisson and Germer with slow electrons and by G. P. Thomson with fast electrons. Thomson fired a stream of electrons through a crystalline film of gold. Knowing the structure of the gold and the speed and

[1] Abstract of a lecture given before the Royal Institution of Great Britain, on March 5, 1937.

mass of the electron, he was able to apply a quantitative test to de Broglie's law, which his experiments fully confirmed.

How are we to think of these waves which guide the electrons in their passage through the gold film? Experiments show that they only come into action when the electrons are moving through matter; in empty space there is nothing in the behavior of the electrons to betray their existence, and yet our experiments tell us that these waves are all pervading.

If you look at a fish swimming in water you will see that he is guided in the direction in which he moves by a wave motion which passes from his head towards his tail. When in the water the fish is, in a sense, like an electron passing through matter. Should the wriggling fish leap out into the air, he may then be likened to an electron speeding along through empty space, because the directions in which both fish and electrons move are then completely unaffected by their attendant wave motions. The fish model is, however, in reality inadequate; indeed, it does not seem to me to be possible to describe de Broglie's electron waves in terms of any concrete model. Rather must we think of them as something indefinite, like waves of emotion; where such waves are most intense, there will be the greatest chance of finding the associated bodies.

The discovery of the wave properties of moving electrons has provided us with a new and wonderfully powerful tool for the study of the structure of surfaces. Owing to their short wave-length and being electrically neutral, x-rays are very penetrating and can therefore tell us little or nothing about the structure of the surface of a body, although they reveal so much of what lies beneath. Electrons, on the other hand, carry a charge and are therefore so easily deflected by the strong localized positive charges of the atomic nuclei that they can not penetrate more than a few atoms deep below the surface. Thus the information afforded by diffracted electrons is virtually confined to the structure of the surface layers.

Of the several problems relating to surface structure which have recently been successfully attacked by the method of electron diffraction, one of the most interesting is that connected with the nature of polish. The late Sir George Beilby had shown, over twenty years ago, that polish does not simply consist in wearing the projections on a rough surface, but causes a sort of flowing of the surface material, almost as if it had been melted and then smeared like butter over the surface. Beilby concluded that the metal atoms in the final polish layer were all completely disarranged, just as they would be in a sudden frozen liquid. Many workers have since thought that Beilby was wrong, so Thomson, hoping to decide the issue, studied the diffraction of electrons by polished metal surfaces. Now a wave probe, whether it be x-rays or a beam of swiftly moving electrons, can only give information about a body when its structure exhibits some regularly repeated feature or features. Thus, in a crystal or crystal surface, the atoms are arranged in a perfectly orderly manner which is repeated many times when the crystal is not too small. In an amorphous substance, however, the atoms are jumbled up, so that practically the only regularly repeated feature is the size of the atoms, or, in other words, their nearest distance of approach to each other. In such a case, the diffraction pattern should consist only of a few very diffuse haloes; hence, when Thomson found that the electron diffraction pattern of polished metal surfaces consisted of broad fuzzy rings or haloes, similar to those obtained by x-rays from liquids like mercury or from amorphous substances like glass, he concluded that Beilby was right in supposing the polish layer to be amorphous. Somewhat later,

however, Kirchner found that under certain circumstances metal surfaces which were known to be crystalline could also give haloes, a discovery which left the issue still in doubt.

In the meantime, while working on an entirely different problem, Dr. Quarrell and I happened to observe that a thin film of zinc crystals when freshly deposited on a cool newly polished surface of copper gave good electron diffraction patterns characteristic of zinc crystals. The pattern, however, rapidly faded and finally disappeared, although if the copper surface had not been previously polished but was crystalline, no such fading was ever observed. The gradual weakening of the diffraction patterns meant that the zinc crystals were being destroyed and were in fact being dissolved by the polish layer of copper, which thus exhibited a property characteristic of a liquid and not shared by the corresponding crystalline surface.

How easy it must be for liquefaction of even highly refractory surfaces to occur when they are being polished has been admirably demonstrated by Dr. Bowden and Dr. Ridler. They took advantage of the thermo-electric current which flows when two different metals are joined together into a closed circuit, and one junction is hotter than the other. It is easy to measure this current and thus determine the difference in temperature between the two junctions. In this way Bowden and Ridler showed that the temperature of formation of the polish, or as it is now known the Beilby layer, on a metal surface is equal to the melting point of the metal itself.

The study of polish has important bearings upon the problem of wear in engines. The essence of the process of "running-in" an engine is a sort of vigorous polishing action, by which a deep Beilby layer of amorphous material is formed on the working surfaces. The reasons why we want to build up such a polish layer before subjecting the bearing surfaces to heavy loads are two-fold. Firstly, the Beilby layer is harder and tougher than the corresponding crystalline surface. Also, unlike polished surfaces, freshly machined surfaces are not really smooth, but have many sharp little crystalline peaks projecting above the mean level of the surface. Thus the load is not uniformly distributed over new bearing surfaces, but concentrated on to a few almost point-like areas, so that the oil film meant to prevent metal-to-metal contact is easily broken down, with the result that the high temperatures generated when the metallic surfaces rub directly against each other sometimes cause them to fuse and weld together, leading to seizure or bad scoring and excessive wear.

Although the polish layer is formed by a process of fusion and smearing of the flowed substance over the surface, the freshly formed Beilby layer on some surfaces immediately recrystallizes on cessation of the polishing action. This occurs in the case of sapphire. The oxide film normally formed on an aluminium surface is amorphous, but the action of polishing causes it to crystallize into sapphire. This explains why the aluminum piston is liable to cause excessive wear of the engine cylinder. Unlike sapphire, however, spinel, a solid solution of aluminium oxide in magnesium aluminate, on polishing forms a permanently amorphous Beilby layer, which does not recrystallize like the sapphire and so produce sharp projecting crystal corners capable of cutting through the oil film to score the metal cylinder. Thus a thin coating of aluminium-magnesium alloy on an aluminium piston should lead to reduced wear, because the mixed magnesium and aluminium oxides film on its surface is "spinelized" by polishing, and the resulting spinel film remains amorphous and smooth.

# THE NEW YORK STATE MUSEUM[1]

By Dr. C. STUART GAGER
DIRECTOR OF THE BROOKLYN BOTANIC GARDEN

ONE hundred years is a good old age in the life of an individual. Few persons live to attain it. But what is one hundred years in the life of an institution? Harvard College, the oldest school of higher education in America, was two hundred years old, and the University of Paris about seven hundred years old, when this museum began to take shape in the imagination and aspiration of its founders.

The word "museum," in its modern sense, was first applied to the Ashmolean Museum at Oxford. This takes its origin from "Tradescant's Ark" or *Musaeum Tradescantianum*, an assortment of miscellaneous "Rarities" collected by John Tradescant, Sr., beginning in 1625, or earlier. Tradescant's collection, combined with that of Elias Ashmole (1677) was presented to Oxford University and has since been known as the "Ashmolean Museum." This was about 260 years before the New York State Museum was organized.

The Bologna Museum, initiated by the natural history collections of the botanist-naturalist Aldrovandi, about 1600, is approximately 330 years old; the British Museum (1753), 184 years old; the Museum d'Histoire Naturelle, Paris (1793), 144 years old; and the Charleston Museum (1773), in South Carolina, the oldest in the United States, 164 years old. Among "modern" museums, therefore, this one has hardly reached adolescence.

The shortness of the span of one hundred years is emphasized by the fact that the present speaker has known personally every one of the four directors of this museum. How well I recall the afternoon in the winter of 1896 when, as a graduate student in the State Normal College (now the New York State College for Teachers), I had the temerity to call on that great scientist, Dr. James Hall, first state geologist, first state paleontologist, first director of this museum, beginning when it was called the State Cabinet of Natural History. If I had been another noted scientist, I could not have been received with more courtesy and consideration. Even then, I sensed the great opportunity I was enjoying as Dr. Hall, 86 years of age, opened drawer after drawer of his precious specimens, made classic by his study of them. He poured out more wisdom than I was able to absorb, but the inspiration he gave remains to this hour. Moreover, he nearly performed a miracle, for he almost converted an embryo botanist into a geologist.

Strictly speaking, I can not claim acquaintance with Dr. Hall's successor, Dr. Frederick J. H. Merrill, for our meeting was confined to a brief introduction; but Merrill's successor, Dr. John M. Clarke, I knew well. I remember clearly his telling me of his appointment as director of science and of the State Museum in 1904, before it had been publicly announced.

Dr. Clarke was not only an accomplished investigator and administrator; he was a man of broad culture and master of a literary style that has not yet become too common among scientific men. Earl Grey, of Fallodon, writing in his Autobiography of Jowett, the famous master of Baliol College, noted that while Jowett was not a great talker, "what he did say was like the result of distilled thought with a sort of finality about

[1] Address (for botanical science) delivered at the seventy-third convocation of the University of the State of New York, celebrating the one hundredth anniversary of the establishment of the Division of Science and State Museum. Albany, October 15, 1937.

it. . . . It was as if he made thought visual."

Such was the quality of the language of Dr. Clarke in his scientific papers and monographs, which carried on the tradition of high excellence for the scientific output of this museum.

The fourth and present director of the museum, Dr. Adams, is one of the founders, in America, of the new science of ecology (the study of organisms in relation to their environment), and is recognized in scientific circles as one of its leaders. It has been my pleasure to have known him for nearly twenty years, and to have been associated with him in establishing and conducting the journal *Ecology*.

So far as I know, he has never fallen from rectitude but once. In a moment of weakness he recently wrote to me, "My first interest in natural history was in plants." But the insidious influences of the animal world finally undermined his botanical uprightness and now everybody has found him out, unashamed as a zoological ecologist.

From this brief history you will see that I have a personal interest in this centennial celebration far greater and deeper than could have been imagined by those who incurred the risk of assigning me a place on the program.

Now in such museums as those of Tradescant and Ashmole, which I have mentioned, the objects were "often badly placed, and were nearly always arranged in relation to their accidental and not their distinguishing features. Things were disposed according to size, like pipes in an organ, and the two sides of a room had to balance so that the most incongruous objects were often placed alongside of each other."[2] As Murray has pointed out, this was in part a reflection of the poorly organized state of scientific and educational ideas of the time. But the conception of a museum as a "cabinet of oddities," of the curious, the unusual, the amazing or amusing, rather than of the significant and instructive, has had great persistence.

But what is a museum?[3] Dr. Clarke, in his address at the "public opening" of this building, referred to the original connotation of the word as a *temple of the muses*, which he aptly paraphrased as "the shrine of intellectual aspirations." He proceeded to point out how closely the conception of the New York State Museum, as formulated by the regents of the university, approximates the Greek idea.

The museum, as the Greeks understood it, was of primary importance in their intellectual life. The most famous pupil of Aristotle, the botanist, Theophrastus, who died in the year 287 B.C., said in his last will and testament: "First of all, I wish everything about the Museum and the statues of the goddesses to be made perfect and to be adorned in a still more beautiful manner than at present, wherein there is room for improvement." The museum, which he had built for a school, was his first concern, and of equal importance with his religion. Everything about it was to be improved.

The most famous museum of antiquity —that established during the Greek-Egyptian period at Alexandria by Ptolemy I, about 320 B.C.—was, as is well known, a great state institution, comparable to our universities—the intellectual center of its contemporary world, with as many as 14,000 students at the height of its activity. During the past fifty years museums have been steadliy developing in that direction, maintaining as their distinctive feature a collection of objects placed on public exhibition.

But in all the ancient world there was nowhere an institution that corresponds

[2] Murray, "Museums: Their History and Use," p. 206. Glasgow, 1904.

[3] Throughout this article the term "museum" is used to designate a natural science museum, as distinguished from those of art, history, commerce, etc.

to what we now understand by the word museum. The modern museum may be most adequately described in terms of its activities:

(1) *Research* (including exploration) for the purpose of extending and perfecting our knowledge.

(2) *Publication of the results of research*, in both technical and popular form.

(3) *Permanent preservation* of the objects which have been the subjects of research, together with pertinent data.

(4) *Public exhibition* of some of these objects for the purpose of public education.

(5) *Conducting an educational program* of lectures, docentry and courses of instruction, with special community service, such as maintaining a bureau of free public information, trade services, etc.

Such a full picture as this of the modern museum needs continual restatement and emphasis, for the vast majority of those who go through the exhibition halls "to see the museum" have no conception whatever of what goes on behind the scenes. I sometimes wonder how many of those have who are depended upon to provide the necessary funds by legislative act or private benefactions, for some of the fundamental aspects of a museum are least amenable to exhibition.

The supreme importance of preserving the objects of scientific study can hardly be over-emphasized. "The images of men's minds remain in books," said Sir Francis Bacon. How important it is to preserve the images of men's minds is emphasized every time we think of the burning of the great library at Alexandria in 391 A.D. The learned world has never ceased to feel its impoverishment by the destruction of those documents. A similar loss is felt and a similar lesson is driven home by the burning of a portion of the New York State Library and many of its unique archeological specimens relating to the New York State aborigines in 1911.

But the objects preserved in a natural history museum are, for natural science, more fundamental objects than books. We can inherit scientific ideas (preserved in books and libraries), but we can not inherit the experiences that gave rise to those ideas and which give them validity. Each generation must realize them for itself. It behooves us, therefore, to do all we can to facilitate the entering-in to those experiences.

By preserving and exhibiting the objects of study which gave rise to the body of scientific ideas and literature, the museum helps make it possible, for every one who wishes, to repeat the experiences of the makers of science. This enables one to check up on the accuracy of the observations and the basis of the conclusions of others by studying the precise objects they studied.

How impossible it would have been for stories of "barnacle geese," the "Scythian lamb," monkfish, dragons and basilisks, and other fantastic tales of early explorers to have been handed on *and believed* if those explorers had been required, as now, to bring the objects they wrote about home for installation in the local museum!

But to think of a museum as merely a collection of objects on public exhibit is as far from reality as to think of a church as an edifice, or of a university as a collection of buildings. The essential thing about a museum is the scientific and educational activities of its staff. The exhibits are a means to a double end which is the advancement and dissemination of knowledge. The two aims are of equal importance.

This museum had its origin in a program of scientific research; it has been and must always be nurtured by the researches of its staff. The museum of a great state can not be merely a popularizer—a purveyor of second-hand information. The proper installation of the exhibits and their revision from time to time to keep them abreast of ever-

advancing science makes it essential that the museum staff shall include the research type of men, and that they shall be required and encouraged in the tradition of this museum for productive scholarship.

Nor is a museum, as here conceived, confined to its exhibition halls or the building it occupies. It has been said of a great state university that its campus is the state. In the same sense, this museum permeates and should permeate the entire state of New York. Its program of research is to study the natural resources of the state and to publish the results. Its scientific and educational activities always have been and always should be state-wide.

Dr. Adams has asked if I would not speak specially of the botanical work of this museum and of the value of botany from the cultural as well as the practical point of view.

There is not time, in this address, to attempt a full résumé of the botanical publications of the State Regents, beginning in 1831; and others, fifty years from now, will appraise and praise the important scientific work of the present botanical personnel. But in any historical account of this institution, however brief, it will always be essential to mention the work of two botanists—Dr. John Torrey and Dr. Charles Horton Peck, whose contributions during its first 75 years laid indispensable foundations, and made both them and this museum favorably known throughout the scientific world.

I will tell you a true story that is stranger than fiction. In 1818 there was a botanist, named Amos Eaton, who had acquired a wide reputation as a "popular" lecturer on botany and other natural history subjects. So great was his fame that Governor Clinton, in that year, invited him to deliver a course of lectures before the New York State Legislature. It actually happened! And, more than that, this course of lectures was one of the chief causes leading to the establishment of the State Geological Survey.

My story grows stranger and more interesting. Did you ever hear of an inmate of a state prison becoming the chief source of inspiration to a great scientist? In 1810 one William Torrey was appointed fiscal agent to the state prison at Greenwich, now Greenwich Village, a section of lower New York City. William's young son, John Torrey, attracted the attention of one of the inmates, who had been imprisoned for debt. If he had lived in these days he would have been "reorganized"! That inmate was the same Amos Eaton, who later, by his eloquence, helped inspire the legislature to take the first step that led to the establishment of this museum. It was from Eaton that John Torrey got his first inspiration for a scientific career.

Now in studying the botany of a new region, such as New York State once was, the first requisite is to know what the plants are that compose the regional flora, and the early publications of the museum were "catalogues" of the plants growing spontaneously in various parts of the state. It is of interest to note that the second of them, published in 1833, was by a pupil of Torrey, a young man named Asa Gray, who, in time, became the best known and, according to some, the greatest American botanist.

In 1839 Torrey, who had been made a fellow of the Linnean Society (London) in recognition of his high attainments, was appointed "botanst" and commissioned to write a "Flora of New York State." This work, now a botanical classic, was published in 1843 in two volumes of more than 1,000 pages, describing nearly 1,500 species, "with remarks on their economic and medicinal properties."

It was a fortunate thing that the state was able to find a man like Torrey, able and willing to perform this service. The work had to be done, sooner or later, and, if Torrey had not done it, it would prob-

ably, in those days, have been undertaken by some European botanist in a manner less advantageous to American science. Botany had not, at that time, won general recognition as a regular subject of university instruction, and all the while that Torrey was engaged in his encyclopedic botanical research he was, for 28 years (1827–1855), professor of chemistry and mineralogy in Columbia University, and simultaneously, for nearly 25 of those years (1830–1854), professor of the same subjects in what is now Princeton University.

The second great staff botanist, Dr. Peck, I knew and corresponded with. His first paper published by the regents was a "List of Mosses of the State of New York," which appeared in 1866. In the same year, as a young man of 33, he was appointed to carry on botanical investigations for the state and to look after the botanical collections of the State Cabinet. In 1870 the State Cabinet, by act of the Legislature, became "The Museum of Scientific and Practical Geology, and General Natural History."

Dr. Peck's "Report of Botanist" for 1867, not published until 1870, was the first of the long series of 46 annual reports, covering the years 1867–1912 inclusive, and known throughout the scientific world as "Peck's Reports." Each was an important contribution to our knowledge of New York State fungi and to the general subject of mycology. In the meantime, he was also publishing other papers on both fungi and flowering plants, determining specimens for other people all over the country, doing field work, caring for the herbarium, attending to a heavy correspondence without a stenographer, and handling a certain amount of administration.

Dr. Peck began his botanical studies by himself while a student in the old State Normal School, here in Albany, before botany was included in the curriculum. He became state botanist in 1883, and his resignation, necessitated by the infirmities of years, took effect in January, 1915. While in office he described about 2,500 species of fungi *new to science*, the majority of them from specimens collected by himself. For much of his career he had quite inadequate support and a salary that was meager, out of all proportion to the value of his services. He was for many years the despair, the inspiration and a great help to younger students of plant life. His writings will always have to be consulted by any one who undertakes further work on the fungi; they are not exceeded in importance by those of any other American student, and by perhaps only one (Saccardo) in the whole world.

What a remarkable record of scientific activity for one man, beginning before the age of 33 and continuing until he was nearly 80 years of age. During that period many botanists took their introductory college course in botany, attained a reputation, and passed on. For his long life as well as his scientific output, he was a landmark in the botanical world and one of the glories of this museum. In harmony with the museum ideal, the objects of his study were carefully preserved and have contributed to make the New York State Herbarium one of the most important in existence and one of the priceless treasures of the Empire State. In 1916 a collection of mushroom models in wax, by Henri Marchand, was presented to the museum as a memorial to Dr. Peck.

It should never be lost sight of that the credit for the superb work of this museum is due in largest measure to the members of its scientific staff. The work of these men was little understood and of only slight interest to the appropriating powers, who were little concerned as to whether the quarters were adequate; and the compensation was based, not on the value to the state of the services rendered, but on the principle of paying only as much as was absolutely necessary. That the state was able to obtain and hold

the services of these men was due solely to their devotion to science and its high ideals.

It is fitting, on this occasion, to recall that practically all the great museums of the modern world owe their origin and much of their most valuable exhibits to the collections and benefactions of private individuals, including scientists, princes and kings, and only subsequently, if at all, became the property of government.

With reference to the "pure science" work of this museum (in botany and other sciences), the question has, no doubt, already occurred to some one in this audience, "What is the good of knowing all that? Why should a great state spend any money for the study of its wild flowers, or especially of its toadstools and mushrooms?" That question has always been asked and always will be asked, and it will forever be a responsibility of science to try to answer it. Those who ask it are apt to be most readily satisfied by an answer that shows some economic gain resulting from the new knowledge.

There is not time here to point out in detail the advantage to practical agriculture of studies of plant breeding, plant diseases and botanical soil-organisms. According to the statistics of the United States Department of Agriculture, the savings from loss and the gains in production are measured in hundreds of millions of dollars per year.

And if, like Joshua, I could command the sun to stand still, we could summarize the very interesting story of how botanical science has served human needs in helping to solve the problems of soil erosion in the "dust bowl" and elsewhere, of the purification of water supply to our cities, the preservation of seabeaches, the diseases of fruit, vegetables and food fishes, the breeding of new and improved fruits and vegetables and flowers, and in other ways, not forgetting the improvement of our minds and the enrichment of life.

Mr. Joseph Chamberlain in 1898, when secretary for the Colonies, speaking in the House of Commons, said: "I do not think it is too much to say that at the present time there are several of our important Colonies which owe whatever prosperity they possess to the knowledge and experience of, and the assistance given by, the authorities of Kew Gardens [the Royal Botanic Gardens at Kew]." And the director of the National Botanic Gardens at Kirstenbosch, South Africa, who quoted Mr. Chamberlain, added, ". . . what Kew has done, other Botanic Gardens all over the world have done."

And let it be stated here with emphasis, and without qualification, that there has never existed, and does not now exist, a great industry or a commercial activity that does not owe its existence or its continuing prosperity to the fact that some one, some time, endeavored to find out something for the sheer pleasure or satisfaction of knowing it. The electrical industry, with all its myriad ramifications, and agriculture in its entirety, are colossal illustrations of this truth.

Science advances both "by leaps and bounds," and by the steady plodding of trail blazers along uncharted pathways. The "leaps and bounds" are few and far between. They are the contributions of the great intellects that appear only at intervals, and first catch the vision toward which the blazed trail has been leading—the Aristotles, Galileos, Newtons, Linnaeuses, Lyells, Agassizes, Halls, Darwins, Pasteurs and Mendels. They give from time to time the necessary new impetus to the great army of trail followers (investigators), who plod along, many without a particle of genius, collecting facts for the inspired fertilizing synthesizer, whose formulation of some great new conception rejuvenates the work of science as truly as the sperm

rejuvenates the egg-cell in fertilization, initiating a new embryo-idea which fairly stretches the human mind and provides the program of scientific research for another generation or so. Among these conceptions in botanical science are the following:

(1) *The existence and nature of cells,* and the fact that plants and animals are aggregates of cells. This not only placed the science of biology on a new and more rational basis, but became the foundation of the new science of "cellular" pathology and physiology, of such tremendous importance to medical theory and practice. It ultimately made possible the scientific study of heredity. This great generalization was first formulated in a botanical laboratory by the botanist, Schleiden.

(2) *The elaboration of the Darwinian theory to explain the fact of organic evolution.* As is well known, this revolutionized the entire range of human thought, and was based in part on a study of plants by Charles Darwin and others.

(3) *The "Mutation Theory"* of variation and heredity, one of the most invigorating contributions to biological philosophy since Darwin, stimulating thought and initiating a vast amount of illuminating research, was formulated by the botanist, Hugo de Vries, primarily by studies of the evening-primrose.

(4) *The Mendelian theory of heredity.* People have discussed the subject of heredity from Biblical times to the present, but the consideration was first lifted from the futile realm of forensic debate and placed on the sound basis of experimental science by the study of the garden pea by the botanist, Gregor Mendel.

These are only outstanding examples of the great illuminating ideas whose cultural value in emancipating the human mind from bondage and bigotry and superstition is among the most precious possessions of mankind. They are primarily the result of the study of plants without reference to economic ends; they are some of the mental "leaps and bounds" taken by the geniuses of science.

But there is another important consideration, seldom referred to, in discussing the value of accurately observing, describing and classifying natural objects —such, for example, as Torrey, Gray, Peck and others have done for the flora of New York State. This work supplies the atoms and molecules which are indispensable for building up the great mass of botanical knowledge, which is essentially not a mere accumulation of facts, but a body of concepts—of laws and principles. It is such work as theirs that makes it possible for us to think at all, and to exchange thought.

We can not think in terms of individual notions, such as "this good man," "that beautiful person," "my rose," "your orchid," but only in terms of general notions—goodness, beauty, roses, orchids. But, as is well known, general notions or concepts are all derived from individual notions or percepts by processes of comparison and abstraction; hence the vital importance of having the underlying facts accurately observed and classified on a rational basis; otherwise, our concepts are incomplete, inaccurate and misleading, and our thinking is futile.

If our concept of "rose" includes only the flowers we buy under that name from the florist it is incomplete, for the studies of the botanist reveal to us the fact that apples and strawberries, and sweet peas and wisteria belong in the same group or natural order as the roses of the florist and the wild rose.

If, as Theophrastus did, we place all trees in the same class because of their tree-like habit of growth, our concept is inaccurate, for the careful observations and comparisons of the botanist show us that some trees are related to the violets, some to the potato, some to the buttercups, and so forth. Such conceptions come as a genuine revelation to the layman in science, just as they did originally

to the botanist. In fact, such truths were missed completely in the early history of botanical science through the untrained and inaccurate observations of the pioneer students of plants who supplied the data—the atoms and molecules of thought, on which the early syntheses (the classical and medieval body of botanical science) were based.

If it is of any importance for us to have an accurate and comprehensive knowledge of plant life, of nature as a whole, then we must recognize how indispensable it is to have the foundations securely laid by the painstaking work of those who provide the essential underlying data; who can and will devote their time to accurate, thorough and unprejudiced observation and description. They supply the knowledge which is the basis of understanding, which is the essence of science. For example:

The work of Torrey and others has given us information as to what plants grow spontaneously within the borders of New York State. By comparative studies we learn the surprising fact that the flora on the summit of the state's highest mountain (Mt. Marcy) is more closely related to that of sub-arctic regions than to the plants at the base of the mountain. If we rest here we have knowledge but no understanding.

Such work as Torrey's and Peck's and Asa Gray's has given us knowledge of the flora of the east coast of Asia and the east and west coasts of North America. By comparisons we learn, contrary to our expectations, that the flora of eastern Asia is not as closely related to that of western North America as it is to that of the more remote Atlantic seaboard. Here again we had knowledge but no understanding, until the great thinkers of botany, pondering the mass of facts accumulated by the Torreys and Pecks, were able to explain these biological puzzles by reference to events that took place with the advance and retreat of the continental ice sheet during the Glacial Period.

Then we understood. It all seems so simple now; but only one man, Asa Gray, was able to solve the latter problem. And to come to an understanding of problems of such reach and difficulty is to take another tiny step toward the goal we would all like to reach, but never shall—the understanding of the universe, and of ourselves, and the meaning of it all. It is such accomplishments as this that enlarge the mind, and enrich the spirit, and make life worth living.

In the light of such considerations, work like that of Torrey and Peck—the laborious, but necessary, observing, describing and classifying—takes on a wholly new significance.

If a great state is fortunate enough to find some one able and eager to devote his life to studying the fungi of the state, as Dr. Peck did, it should by all means encourage him and subsidize him. If no one had ever studied fungi, we should have had no yeast, which is a fungus. It would exist, of course, just as the bacteria did before Pasteur, but not for us. Whole industries based upon the process of fermentation would never have existed.

But the point I wish to stress is this: Parallel with education, there is nothing more important for the welfare of a people than the advancement of knowledge—nothing more important for a great state to do than to promote this activity, to organize it and to finance it commensurately with its importance. It is correlative with the promotion of law and order, and morals and religion.

Hall and Torrey and Peck and their associates knew that they could render this state and the whole world an invaluable service beyond the mere discovery of mineral and vegetable wealth. That service was the advancement of positive knowledge.

The first director of this museum might

have restricted his energies to the endeavor to locate coal, oil and minerals in the rocks of the state. Quite possibly that was the official expectation. But he also became the "founder of stratigraphic geology and applied paleontology in America" (W. J. McGee), and "laid the grounds for a rational theory of mountains, which must be regarded as one of the most important contributions to geological science" (Hunt).

A museum is an organic thing. Its germ is an idea. Its essential characteristics are activity and growth. It depends upon nourishment. It remains useful only so long as it continues to perform vital functions. Whenever it becomes merely a static exhibition of labeled objects it has become, not a museum, but a mausoleum.

Like the so-called coral reefs, what it does to-day should become the foundation of what it will do to-morrow. Those who have labored through the first brief hundred years of its life have only laid foundations; but like the foundations of a building, they largely determine the form and proportions of the superstructure. And how can a builder proceed with a superstructure unless he gives careful attention to the foundation?

This is the purpose of anniversaries—not primarily to exult over the past, however glorious it may be, but to make sure that the work of to-morrow shall rest securely on the foundations that have been laid, and by a brief survey of the accomplishments, and especially the personalities of the past, to gather new inspiration and vision for the work that must go on, and on, and on—so long as anything remains unknown and mankind retains its God-given desire to know. These are the eternal prerequisites of science and education.

Let us not be impressed with the idea that the New York State Museum is 100 years *old;* it is 100 years *young.* It has all the characteristics of youth—it is still outgrowing its garments of yesterday; it is still learning; it has the vigor and aspirations and curiosity of youth; it has the urge and the will to achieve; its career is mostly ahead of it; it is forward-looking.

May the promise of its youth and the need of its services, as well as the invaluable accomplishments of its past, impress the powers that be to provide the necessary funds, not only for the more nearly adequate building which it merits, but to continue its record of a scientific and educational staff of the most able men to be had, who will effectively carry on the glorious tradition of personalities and accomplishments which have commanded the admiration and respect of the learned world for the past hundred years. No money could be appropriated by the legislature of any state that could have fuller justification or yield larger returns on the investment.

I could not close more fittingly than with a quotation from Dr. Clarke's address, delivered twenty-one years ago at the "public opening" of this museum: "All that has been achieved," he said, "in the making of the State Museum is overshadowed by the hopes of its greater service to the public."

# SCIENCE AND DEMOCRACY[1]

By J. McKEEN CATTELL

Haply the swords I know may there indeed be turned to reaping tools,
Haply the lifeless cross I know, Europe's dead cross, may bud and blossom there.

THUS, as told by our poet, spoke Columbus in his prayer, taking his way along the island's edge. From that day, October the twelfth, 1492, we may date, in so far as a continuous process of evolution may be assigned a beginning, both modern science and modern democracy. The circle of the earth was closed by a scientific discovery following patient induction, bold theory and persistent labor; at the same time a new world was opened for the democracy in which we live.

Without science there could be no democracy. It is the application of science to agriculture, commerce and the arts that has made democracy possible. So long as food, clothing and dwellings were produced and transportation was carried forward by unaided manual toil, so long as plague and famine, disease and premature death were unchecked, it was impossible to give equal opportunity to all. Plato had to provide slaves for his republic; serfs and peasants have been partly emancipated only in our own time. It is the applied science of the past hundred years that has made child labor needless and universal education possible, that has made the still existing semi-slavery of industry wanton and intolerable.

[1] Convocation address given at Indiana University in 1912, now printed without alteration after the lapse of twenty-five years. It has a certain historical interest (at least to the writer) for it appears to be the first statement of the dependence of modern civilization on the applications of science. An excuse for the rhetoric may be found in the circumstance that the address was prepared for a general audience.

Science there had been and a kind of democracy, notably in the marvelous efflorescence of the Greek period, the radiation of whose light has never since been wholly quenched. The glimmering of the so-called dark ages was dawn rather than twilight. The vigorous tribes of the north partly submerged and partly assimilated the culture of the Mediterranean. Sacerdotium, Imperium, Studium—the church, the empire and the universities—these institutions both resisted and spread the spirit which on the one side gave birth to trade guilds, trial by jury and constitutional governments, and on the other to art, literature and science; for personal liberty and intellectual performance have advanced together.

Salerno, the earliest of universities, was a school of medicine, and for centuries maintained its prestige as such, coordinate with Bologna as a school of law and with Paris as a school of theology. At Salerno in the eleventh century women were among the teachers and Jews were not debarred. The university probably developed from the municipal schools of the Roman Empire, and this also holds to a certain extent for Bologna. When at the beginning of the twelfth century, Irnerius lectured at Bologna on civil law, the Italian cities were attaining their independence, resisting the emperor on the one side and the pope on the other, subduing the feudal lords of the surrounding country and the bishops within their walls.

With the rising tide of democracy came commerce and the industrial arts; population and wealth increased incredibly amid incessant wars. The civic life of those republican cities of northern

Italy paralleled that which had flourished fifteen hundred years before in the Greek democracies. From it came the renaissance of letters, art and science, the foundation of universities. In 1265 was born Dante, second "among the sons of light," master of the science of his day, prior by election of republican Florence. Imagine this town of Bloomington, about the size of Florence, having a Dante to elect as mayor, a Giotto to paint his portrait—and think of those two hundred years of Florentine history, genius so diverse as shown by Boccaccio, Macchiavelli and Savonarola; the great performances in architecture, sculpture and painting, culminating in Leonardo and Michelangelo.

Migrations from Bologna in the twelfth and thirteenth centuries established universities in a number of Italian cities, that of Padua becoming the most famous. While the Roman civilization to a certain extent survived in Italy, such scholarship as existed north of the Alps was carried there by the church. The old imperial and municipal schools were swept away by the barbarian invasions; but schools were established in the monasteries and cathedrals. Abelard lectured on theology and philosophy at Paris in the cathedral school of Notre Dame at the same time that Irnerius lectured at Bologna on civil law.

Thence followed the University of Paris with its dominant interest in the scholastic philosophy. Unreal as most of the dialectic appears to us, it was a true advance in scientific method to argue as Roscellinus and Abelard did that faith depends on reason. Paris was becoming a political, industrial and commercial center; guilds were established; there were struggles for municipal liberties and constitutional guarantees. The Counts of Paris became the Kings of France. The crusades on the one hand, the universities on the other, brought men together from all the nations of Europe. Paris became their intellectual goal.

The conditions leading to the development of Oxford as one of the three most notable medieval universities are somewhat obscure. The place was convenient of access and chance appears to have drawn to it a migration of English scholars from Paris in 1167. But Oxford became great because Great Britain then as always produced great men. In those days the university led in science and mathematics. Grossetête lectured on optics and wrote on agriculture; his pupil, Roger Bacon, was the prophet of the inductive sciences.

Bacon was perhaps born in 1215; in that year King John was forced by the barons to sign the magna charta. This instrument which reaffirmed the Saxon laws is regarded as the foundation of English liberty and constitutional government. The king was made subject to law, and the barons granted to their vassals the privileges they obtained from the king. No freeman was to be imprisoned or fined except by judgment of his peers or by the law of the land. The only mention of the villains or serf-peasants is that their implements could not be taken away by fine. The barons and the kings were not concerned with democracy, but their centuries of quarrels led that way.

Political and social democracy had to await the slow development of science; only the nineteenth century supplied the applications of science to industry, agriculture and commerce, to the limitation of disease and premature death, which make it possible for the twentieth century to develop a true democracy. None the less it is the case that the parliament which had its beginnings at the time Roger Bacon was born has developed with the growth of science until to-day, when Great Britain has the most democratic government hitherto attained by

a great nation. England has had the most continuous leadership both in scientific productivity and in parliamentary and democratic government.

From the time of Roger Bacon to the time of Columbus and Copernicus, universities were founded throughout Europe. If the University of Padua had not been established, and if Columbus had not studied there as a boy, he might have been an adventurous sailor, but he would not have discovered the West Indies. If the University of Cracow had not been established and if Copernicus had not found there and at Bologna and Padua teachers of mathematics and astronomy, he might have been a canon at Frauenburg, but he would not have written on the rotation of the celestial bodies. If the University of Wittenberg had not been established in 1502 and Luther had not five years later become a professor there, he might have remained a monk in the Erfurt convent; he would not have led a procession of professors and students from the gates of the university to the market place to burn there "the execrable bull of antichrist."

Luther had the support of the university in which he taught, but his books were burned at the University of Paris. It is the thesis of these remarks that universities and scientific men have been the causes of political and social democracy, and consequently that their support and encouragement should be one of the principal concerns of a democratic government and of a democratic people. But the ways of providence are indirect. While the ultimate effects of universities and of those engaged in scientific research and invention have been to make democracy possible and necessary, their immediate influence has usually been on the side of conservatism, in support of the king, the aristocracy and the church. Universities have been dependent on church and state and on wealthy patrons; scientific men have come in the main from the kleptocratic classes or have been absorbed into these classes. Those only can obtain the prolonged training required who come from families having money or who depend on some charity for their education. Scientific research and invention are not paid for by the people whom they benefit; the rewards have been patronage and social recognition.

Copernicus was a canon of the church: he dedicated the "*De revolutionibus de orbium coelestium*" to the pope and delayed its publication until the end of his life to escape possible censure. Columbus was strict in his piety; one of the main objects of his voyage was to convert the Grand Khan to Christianity. He sought through the courts of Europe for a patron. Kepler was court astrologer. Galileo received pensions from the Medici and from the pope; he denied his own science. Descartes suppressed his book on hearing of Galileo's troubles; his favorite disciples were Princess Elizabeth and later Queen Christina, in attendance at whose court he died. Harvey was physician to King Charles and attended him in the battles of the civil war. Cassini and Huygens went to Paris under the patronage of the king of France. Hobbes was tutor to the nobility and to the king, whose divine rights he championed. Newton gave up his professorship at Cambridge to accept a lucrative position in the mint; he wrote on the scriptures and was a welcome visitor at court. And thus the list of lesser founders of science might be rehearsed—they came from the upper classes, or from the middle classes that were at the same time exploiting and subservient. They had little wish to promote radicalism and democracy, but they did so far more effectively than any agitators or any legislators who have ever lived.

De Candolle found that of 100 foreign associates of the Paris Academy of Sciences, 41 came from noble and wealthy families, 52 from the middle class and

seven from the working class. Galton found that of 96 contemporary leading men of science, only one came from the artisan or peasant classes. Odin found that of 823 French men of letters, 65 per cent. came from the nobility and governing classes, 23 per cent. from the professions, 12 per cent. from the commercial and middle classes and 16 per cent. from the lower classes. The working classes outnumber the privileged classes a hundred to a thousand fold, but produce less than one quarter as many men of performance. If the working classes have equal ability and if they had been given equal opportunity, instead of a hundred scientific men of the rank of the foreign associates of the Paris Academy there would have been from four to forty thousand. It may be that the peasant and artisan classes in European countries are separated from the upper classes by an inferior heredity; but that is not the case in America. Five or ten generations back we all have ancestors of the same average social standing; any selection for ability within this short period must be slight and transient.

The emotional appeal to the sense of justice and sportsmanship for democratic equality of opportunity is compelling; the scientific argument for its wisdom is convincing. A hereditary aristocracy of wealth may for a time establish standards of manners and of fine living; it may foster science, literature and art. But its performance is trivial in comparison with what will be accomplished when each is given opportunity in accordance with his ability. This end has been more nearly approached in America than elsewhere. If it is asked why then we have not done more, the answer is that to have done this is the greatest of achievements. The more equal division of opportunity decreases the special privileges of a few—traditions and leisure are lacking. To educate a hundred million people by way of the yellow journal and the moving picture to what is of most worth in conduct and in life is of necessity a slow business. Measureless increase in wealth and knowledge will surely come. Whether the race can conduct its affairs better in riches than in poverty, by reason than by instinct, is the question confronting us.

Shortly before the discovery of America by Columbus and the instigation of the protestant revolution by Luther, printing was developed and movable types were reinvented, an advance in civilization only paralleled by the invention of the alphabet. It is difficult to conceive how there could have been some seventy-five universities throughout Europe before the time of the printing press. This appears to be an essential condition of general education and scientific progress as these are essential conditions of social and political democracy. It would take ten days to copy by hand the contents of a newspaper which is sold for two cents. All the people in America would need to spend their entire time to write part of what they now print. Unfortunately we print and read much that is unfit. It is a fundamental defect of our civilization that science has increased the means of production beyond our power to distribute fairly and to use wisely what is produced. The natural sciences and their applications have preceded the mental and social sciences and their applications. Investigation of the conditions of conduct and of its control is the great scientific problem of the future.

Raffael was born in the same year as Luther, two contrasted men, each typical of the country in which he lived and of the kind of work he did. Leonardo da Vinci and Michelangelo, both eminent in science as well as in art, Raffael and their contemporaries, under the patronage of the Medici in Florence and of the popes in Rome, carried the art of the Italian renaissance to its culmination,

perhaps to the beginning of its decline. Despotism and luxury were in control; but the genius of Italy did not fail. Galileo was born on the day on which Michelangelo died; art then yielded its supremacy to science. In the religion of positivism February the eighteenth, 1564, should be commemorated in the largest red letters of the saints' calendar.

Galileo in Italy, Descartes from France, and Hobbes in England are the founders of modern science; to them we owe the fundamental concepts of a mechanical world, the invariability of the relation between cause and effect, the complete lawfulness of nature. Galileo stands first both in time—he discovered the isochronism of the pendulum at the age of nineteen, five years before the birth of Hobbes and thirteen years before the birth of Descartes—and in performance. Hobbes and Descartes were primarily philosophers—lovers of wisdom or sophism as the case may be, devisers of castles without concern as to whether they stand on the rock or float in the air. Galileo was a man of science, so completely armed that the succeeding three hundred years have not seen his like.

Newton was born in the year in which Galileo died; scientific leadership passed from Italy to England. In that year, 1642, the conflict between King Charles and the parliament culminated in civil war. In answer to the parliament the King replied: "Should I grant these demands. . . . I should remain but the outside, but the picture, but the sign of a King." The parliament had its will, and Great Britain, though it remains a social aristocracy, has attained a democratic government more complete than ours. The ministers are directly responsible to the commons and to the people; there are no constitutions and courts to dominate the legislature.

Cromwell represented Cambridge in the long parliament; but the university, like Oxford, was loyal to the king. This has been the habit of universities, the natural homes of "lost causes and impossible loyalties." It is one of the dramatic ironies of history that the university, standing under the shadow of church and state, endowed by pious and aristocratic patrons for the education of the clergy and the upper classes, should by the inherent nature of knowledge subvert the old orthodoxy and the old privileges. It is only the metropolitan and provincial English universities and most of all our own state and urban universities that are directly responsive to the utilitarian democracy on which they depend. They suffer in dignity and in distinction; they lack traditions and leisure; but their crudeness and immaturity only display the vigorous youth to which the future belongs. It is not ignoble to follow in the steps of Milton, the radical, who abandoned his poetry for twenty years to engage in the rough struggle for liberty. As he says to himself: "Ease and leisure was given thee for thy retired thoughts out of the sweat of other men." But he reflects that if he had been as dumb as a beast when the cause of God was to be pleaded, he would have been that which his own brutish silence had made him.

England had enjoyed her great Elizabethan era in poetry and in adventure; a scientific period followed. Bacon drew up a code of scientific procedure with the authority of a lord chancellor; Hobbes made mechanics the basis of his philosophy. At the same time nature was studied at first hand. Gilbert's work on the magnet was produced contemporaneously with Hamlet, Macbeth and Lear. Harvey's work on the circulation of the blood appeared five years after Shakespeare's words were printed:

> As dear to me as are the ruddy drops
> That visit my sad heart.

Sydenham, Hooke, Grew, Boyle and others carried forward scientific investigations. Then came Newton, whose

primacy in science can only be challenged by Aristotle and Galileo.

It was by no means an age of liberty and democracy; Cromwell ruled as a benevolent tyrant; England was ready to take back its Stuarts and when they proved intolerable to exchange them for Hanoverian princes. In France, Louis XIV and Richelieu lorded it with a high hand. The states-general were not summoned from 1614 until the eve of the revolution. The court and the nobility were saturated with extravagance, folly and sin; the people were oppressed intolerably. In Germany the thirty years war reduced the population to less than one half. In a crude and small way the courtlets and princelings followed Versailles. There was no representative or parliamentary government; the people were there only to be taxed and killed. Conditions were worse, if that be possible, in southern Europe. The Italian provinces, ruled by despots, were the playthings of the courts north of the Alps. In Spain the period of letters and art, of Cervantes and Velasquez, was not followed by a period of science. The inquisition burned at the stake 30,000 victims and imprisoned ten times as many. The Protestants in Austria, the Huguenots in France, the Jews in Spain, were killed or driven away; a suppression and redistribution of intellect and character was effected that lasts to the present day. Of special interest to us is the migration of Puritans and other dissenters to America. They were selected men and women, and the country was largely peopled with their descendants. There was a second selection for independence and ability when the central states were settled by migrations from New England, and we have here a population of remarkable potentiality, most of its Lincolns mute and inactive through circumstances.

An age of despotism and oppression is not necessarily inimical to literature, art and science; nor is an age of freedom and democracy necessarily friendly to them. On the contrary, the lavish extravagance of kings, princes and nobles has often given opportunity for a display of genius, while a sober and righteous people may look askance at such things. But luxury consumes its children, whereas democracy and equal opportunity may prepare the ground to produce flowers as well as fruits. In the course of the seventeenth and eighteenth centuries, Italy and Spain, France and England, seemed to fail in genius as well as in freedom. There was a rough exhibition of democracy and equal opportunity in that any adventurer might become a general; a prelate, or a courtesan from any class of society might rule the court. Above all there was working in the mass of the people the ferment leading to the great movement of democracy and science of the nineteenth century. In the north Prussia and Sweden were preparing for their parts, and semi-barbarous Russia was emerging to the destiny not yet fulfilled. At the same time far-off America was laying the foundation of its present civilization. Prediction is futile, but it is also harmless, so there is no objection to fancying that the United States, Russia and China will play the chief parts in the history of the coming century.

These reflections began by dating science and democracy from the discovery of America by Columbus; with unabated patriotism I venture to date recent science and democracy from July 4, 1776. Certainly the discovery of America and the declaraton of independence are not so much causes as signs of the two greatest world movements. But for us in this country they mark turning-points or starting-points in history. The modern period has given us in art, the music of Bach, Beethoven and Wagner; in literature, the novel; but all other human achievements pale in the blinding light of science and democracy.

Let us once again call to mind that science with its applications is the cause of

democracy, while the debt of democracy to science remains to be paid. In a single century science has doubled the length of human life and reduced to one fourth the manual labor required from each. The heritage which science has conferred on democracy has been but partly and imperfectly used. Wealth and opportunity are still distributed with scandalous disregard of the principles we profess. If we still kill one fourth of our children in some places; if we still give nine tenths of our boys and ten tenths of our girls no equality of opportunity; if we permit not only men, but also children and women, to work ten hours or more a day in unhealthful occupations; if we allow tariffs and trusts to take from the poor to give to the rich; all this is not the fault of science. It is now the business of democracy to give science the chance to increase to the limit the economy of production and the conservation of health, while at the same time directing its chief care to developing the sciences concerned with conduct.

However artificial it may be to date the modern movement of science and democracy from the declaration of independence followed by the French revolution, it is less so than to date it from the calendar beginning of the nineteenth century. Voltaire and Rousseau, having made straight the way for the French revolution, died in the same year, just after the beginning of our revolution. Goethe was born in 1749, Schiller and Burns ten years later, Wordsworth in 1770. Our revolution was academic: it but confirmed the existing state of affairs and passed from precedent to precedent; Washington, Jefferson, Franklin and Adams were only rebels by force of circumstances; our constitution guards and limits the freedom of the people. The French revolution was melodramatic and led directly to Napoleon.

But contrasted as they are, the American revolution and the French revolution ended forever the old disorder of the world. We complain pretty continuously about our social and political institutions—and sometimes we try to improve them. We may well look with hope to the future when we recall what science and democracy have accomplished within two hundred years—since the time when the entire population of a country might be reduced to half by war, pestilence and famine, since a convent or a king's court might be a brothel, since a French noble in the course of the chase might kill a peasant to warm his feet in the entrails, since even in this country puritans might burn witches and cut off the ears of Quakers.

With advancing political and social democracy there was an extension of science as well as a renaissance of letters. Unlike art and letters science has moved forward continuously in almost every direction and in almost every country. Italy has not again produced a Galileo, nor England a man like Newton, unless it be Darwin. But the foundations that they laid have been built upon in a way that does not hold for the art of the Italian renaissance or the drama of the Elizabethan era. Newton, Huygens and Leibnitz had successors to carry forward their work and to open new lines of which they did not dream. In spite of the marvelous accomplishment of Newton, Laplace, born twenty-two years after his death, carried celestial mechanics to even greater perfection. Kant and Laplace introduced, though somewhat incidentally, the conception of cosmic evolution. Science made quantitative by Galileo and Newton then became also genetic; these are the two great methods of science. The doctrines of the conservation of energy and of organic evolution have given complete exemplification of the quantitative and of the genetic methods.

In so far as the advancement of science and the progress of democracy are movements important to the world beyond all

others, knowledge of the causes of these movements is of more worth than any other knowledge and the power to control them is of greater consequence than any other power. It is our business to obtain this knowledge and to acquire this power. My argument is that science has been the cause of democracy. If wants are very simple, it is possible to have a kind of equality of opportunity and of resources, as among the lower animals and savages. When conditions become more complicated, society is thrown into a patriarchal, or feudal, or despotic, or oligarchic system. The material resources are not sufficient to provide adequately for all; the stronger seize on them, and the many must toil in ignorance and poverty in order that a few may have knowledge, leisure and luxury.

But with the applications of science to industry and commerce, to the prevention of disease and premature death, it again becomes possible to provide equality of opportunity and adequate resources for all. The period of childhood and youth can be used for universal education, so that each is given the chance to prepare for the work for which he is best fit, and at the same time to obtain the wider outlook that enables him to take his share in a democratic government and to appreciate the things in life that are of most worth. Science has made political and social democracy possible and has given us so much of it as we have. It should be the chief concern of democracy, in order that it may become secure and complete, to promote the further extension of science.

An aristocracy of wealth and leisure has been in the past more favorable than a democracy to science and art. There are in it those who are able to answer the call of science—think what the world would have lost if Darwin had not possessed inherited wealth—and appreciation and honors are given as rewards. But democracy will surely in the future do more for science; it will give not only to a small class but to every one the opportunity to use the talent that he has, and it will find means to reward scientific work, not by titles and honors and positions, but by the good democratic method of paying for work what it is worth.

The great obstacle to the advancement of science is that research can not be undertaken as a profession, each man earning his living by his work and being rewarded in proportion to its value. The physician is paid for curing and even for killing his patients; but not for the research and discovery which have done more to diminish suffering and disease than all the practice. The engineer is paid for the particular work he does, but scarcely for the improvements in method which make further work cheaper and better. Scientific research has been dependent on the instinct of curiosity and of play directed to its highest end; organized society has done nearly as much to thwart this instinct as to reward it. The work which is of benefit to all the people should be paid for by all the people. Monopolies, which make it possible to charge more for a service than it costs, must be controlled by the government; scientific advances and other services rendered to all without cost to them must be rewarded by the state, which only has the power to collect the value of the service from those benefited.

Something has been accomplished. Among the comparatively small number of powers assigned to the Congress by our Constitution is "To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive rights to their respective writings and discoveries." Municipalities, states and the nation are learning the wisdom of employing scientific experts both in economic work and in pure science. But since the foundation of the universities of Salerno, Bologna, Paris and Oxford, the natural home of scientific research and creative

scholarship has been the university. This was most completely exhibited in the German universities of the nineteenth century, which gave that country the primacy in science that it holds.

Men were chosen for university chairs as a reward for research work and as an opportunity for further work. The selection was fairly democratic, for if a student could follow a university course his future career depended on his ability. If he succeeded he became a member of an aristocracy of scholars. In America we have not had a leisure class, as in England, interested in science, nor until the last quarter of the last century universities, as in Germany, in which research work was cultivated. These conditions explain the backwardness of the country in science. We can not afford to keep a leisure class for certain desirable by-products; it is more economical and in every way better to pay directly for our science. We are now beginning to do so. Our government spends more than any other on its scientific work and the quantity is greater. We may hope that the lack of distinguished quality is not due to inferior racial genius, but to inadequate rewards, appreciation and opportunity. Democracy does not mean equal mediocrity of all, but performance by each in accordance with his ability.

Of our thousand leading men of science, only eleven may be classed as amateurs; 106 are in the government service; 738 are engaged in teaching, nearly all in a few universities. Our scientific research is thus in the main dependent on the universities as has been the case in Germany. To them we must give credit for the work that they have made possible; on them must be placed the responsibility for our failure to do more. We may hope that the comparative sterility of our universities is in the main due to the recentness of their establishment, and to the stupid methods of autocratic control that have resulted from newness and haste, rather than to lack of genius in the people. We may look forward to the time when the numbers of students, the cost of buildings and the complexity of the administrative machinery will be subordinated to the personality and the performance of great men.

The discovery of America marked a new period for science and for democracy; the foundation of the nation reflected the progress of knowledge and of liberty; for a third time it is possible to associate our country, if only by way of coincidence, with their further advance. Darwin and Lincoln were born on the same day. At nearly the same time the "Origin of Species" was published and the slaves were emancipated. Freedom of thought and freedom of action received together their complete expression. Never again will truth be permanently suppressed; never again will men be held in legal slavery.

With the ebb and flow of the secular tides, music, poetry and art may blossom and then wither; the family, the church and the nation may pass as they have come; but the stream of science and of democracy will flow ever onward, enlarged by every spring and brook from all the land. They will surely complete their perfect work. To every child will be given his heritage of happiness and opportunity; men and women will find the work for which they are fit and the reward that they deserve. The wealth now wasted on armaments, futile luxuries, idleness, preventable disease and crime will be devoted to new advances in science which in turn will provide new opportunities. To all nations and to all men will be given according to their needs; from all will be received according to their ability.

The swords we know will then at last be turned
to reaping tools;
The cross we know, the world's dead cross, will
bud and blossom then.

# THE PROGRESS OF SCIENCE

## SCIENCE SPEAKS AT INDIANAPOLIS

In certain respects the annual meetings of the American Association for the Advancement of Science are the most important scientific conventions held in the United States and perhaps in the world. The meeting of the association that will be held in Indianapolis, Indiana, from December 27 to January 1, inclusive, will illustrate the statement.

If mere size were a proof of importance the meeting would rank very high, for within six days more than 1,250 addresses and papers will be presented in 225 different programs. If wide geographical distribution of those attending the meeting were taken as the criterion of importance, it would still rank high, for scientists will assemble at Indianapolis from nearly all parts of North America. If diversity of subjects considered were the basis for judgment, the meeting would rank superlatively high, for its programs cover essentially all the wide field of pure and applied science. They range from the abstractions of pure mathematics to remedial reading for the dull; from cosmic rays to the growing of potatoes; from prehistoric Indians to current economic theory.

The Indianapolis meeting has, however, much better claims to being important than mere size or diversity of interests. To a considerable extent its programs are concerned with coordinations and integrations of various fields of science. A century ago science consisted largely of *natural philosophy* and *natural history*. Having become by that time thoroughly impregnated with confidence in the orderliness of nature and the soundness of the experimental method, like a fertilized ovum it rapidly divided and subdivided into more and more branches, each growing with all the vigor of its parent. With this subdividing of science there have inevitably developed specializations roughly analogous to those in growing organisms. Although a specialized organ may be, for limited purposes, much superior to one whose functions are more general, yet it is much more dependent upon related organs. Similarly, the more specialized a science is the more dependent it is upon other sciences.

The scientific programs of the meetings of the association are organized by its sixteen sections, each representing such a scientific field as physics, chemistry or the botanical sciences, and by its 163 affiliated and associated societies. Of the affiliated societies, eighty-two are strictly professional scientific societies and thirty are academies of science. Of the associated societies, twenty are professional scientific organizations. Forty-one of these affiliated and associated societies are meeting with the association in Indianapolis. The combined membership of these societies (including duplications) is now approaching a million. These figures indicate the amazing growth of science within the lifetime of the association and the magnitude of the problem of coordinating and integrating it for the benefit of society as a whole and of human beings as individuals.

There are two ways in which meetings of the association promote correlations among the sciences. One is the unparalleled opportunities they provide for scientists in different fields to mingle with one another and to exchange ideas. As all scientists know, there is more than a grain of truth in the definition of a specialist as being one who knows more and more about less and less. Specialists are necessary, and so are integrationists (to coin a word) if science is to realize its high possibilities. The meetings of the

association tend to make integrationists out of specialists.

Another and more direct way in which meetings of the association promote syntheses of science is through symposia. For example, the Section on Chemistry has organized a symposium on "The Applications of Surface Chemistry in Biology," which will be participated in by five distinguished scientists. The purpose of this symposium is to examine and explain the fundamental processes involved in the metabolism of living organisms. The Section on Geology and the Geological Society of America have organized a joint symposium on "Petroleum Geology of the Illinois-Indiana Basin," a subject having not only scientific but economic interest.

In the symposium on "The Endocrines as Related to Behavior" psychology, physiology and medicine are concerned. The one on "The Relationships between Insects and Plant Diseases" involves entomology, botany, horticulture and agriculture. "The Maya Civilization" symposium is sponsored jointly by the Section on Historical and Philological Sciences and by the History of Science Society. The chemists, agronomists and horticulturists are uniting in a discussion of the recently discovered effects of minor chemical elements on the growth of plants. Psychologists and educationists (to coin another word), agriculturists and botanists, plant physiologists and horticulturists, chemists and physicists, zoologists and geneticists and other cooperating groups will hold joint meetings or have joint luncheons or dinners. The inspiration and broadening effects resulting from these minglings of scientists can not be easily overestimated.

There is another somewhat different type of symposium that is illustrated by those organized by the Section on the Medical Sciences. The distinguishing characteristic of these symposia is that they present in an organized form essentially all that science now knows on some important subject. For example, at the Atlantic City meeting a year ago the subject was the cancer problem, all phases of which, from that of heredity to the therapeutic effects of radium and x-rays, were treated by eminent authorities. At Denver last summer the subject was the class of micro-organisms that cause tuberculosis, leprosy and a few other diseases. In Indianapolis, it is syphilis. The cancer symposium has been published in a fine volume, and the one presented in Denver is now being printed.

It is easy to overlook the fact that science is the most powerful force operating in the world. As astonishing as are its direct technological applications to living, they are probably much less important than their impacts upon the economic social and governmental organization of society. The Section on Social and Economic Sciences has organized for the Indianapolis meeting the first of a series of conferences (symposia) on the broad subject of "Science and Society." It is inspiring to find scientists through their broadest and most influential society setting themselves seriously to examining the effects of the impact of science upon society. There can be little doubt that along that road lies the most desirable goal for civilization.

Finally, the meetings of the association represent the spirit and conscience of science. Through press reports and over the radio its voice reaches throughout the land. It calls for cooperation among men, not strife; it exalts freedom of the spirit, not arbitrary control; it promises heaven on earth, not in a vague beyond. That it permeates and enriches all the deep currents of life is illustrated by the subject of the retiring presidential address of Dr. Edwin G. Conklin—"Science and Ethics."

F. R. MOULTON,
*Permanent Secretary*

## SYMPOSIUM ON BIOPHYSICS

A SYMPOSIUM on biophysics was held on November 4, 5 and 6 in Philadelphia. The first large meeting devoted to this borderland field, it was sponsored by the American Institute of Physics in cooperation with the Eldridge Reeves Johnson Foundation for Medical Physics of the University of Pennsylvania. The sessions were held in the University Museum.

The meeting served two principal purposes. It marked a stage in the progress of those fields of biological research in which the methods and results of physical research play a large rôle, and it provided a forum where research men of this field might meet. The program reflected this two-fold character. The first two days were devoted to invited papers by twelve leaders of research. Their topics ranged from those almost exclusively of interest to biologists to others which are of as great interest to the pure physicist as to the biologist.

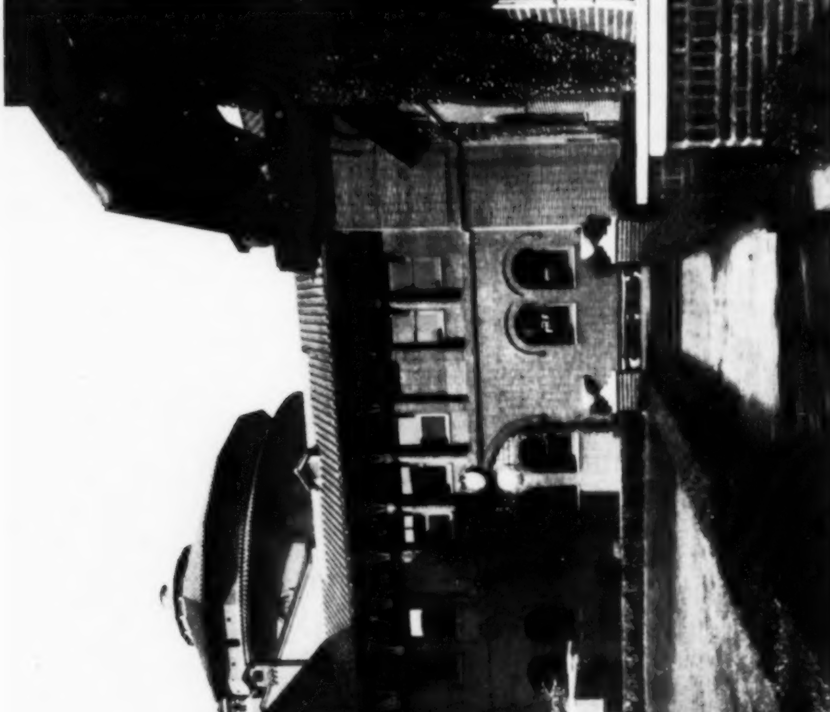
In the evenings of these two days, Dr. Irving Langmuir presented the first two of his Johnson Foundation lectures on "Monolayers and Multilayers and their Applications to Biological Problems." The third day of the meeting consisted of two parallel sessions in which some thirty short papers were presented on the subject of current researches and their results.

The meeting was opened by Dr. John T. Tate, chairman of the American Institute of Physics, who introduced Dr. Alfred Stengel, vice-president in charge of medical affairs of the University of Pennsylvania. Dr. Tate, in his introduction, referred to the desire of the institute to provide increased opportunity for the development of those fields of allied sciences in which physicists can make contributions of direct value. He referred to the admirable research program of the Johnson Foundation, stating that it was this and the general activity in biophysics in and near Philadelphia which led the institute to choose that city for the meeting. Dr. Stengel welcomed the symposium for the university and traced the history of the Johnson Foundation in its relation to the growth of biological research with the aid of the methods of physics.

The latter theme was expanded by the next speaker, Dr. Detlev W. Bronk, director of the Johnson Foundation. Dr. Bronk referred to the subject-matter of the field, but placed his emphasis on its position in the totality of human interests and the general need for integration of the subdivisions of science. While there is general recognition that the field exists and is important, its development is hampered. Too few students learn physics and biology together from the ground up. There are too few positions of sufficient attraction open for them to fill. Dr. Bronk expressed the hope that more foundations in biophysics would come into existence, that every large physics departments would have one or more staff members primarily interested in the biological aspects of physics, and that biological laboratories, hospitals and medical institutions would see that the services of competent physicists were directly available to them.

Dr. E. Newton Harvey, of Princeton University, spoke on "The Physical Properties of Protoplasm," although, as he said, his subject was really necessarily the cell as a whole. Modern biophysical study of the cell rests on the techniques of classical physics and microscopy. By observed motions, displacements and distortions, occurring as a result of known forces, such as centrifugal forces, the viscosities and the tensions at the surfaces of cells can be found. Dr. Harvey illustrated his paper with slides and with motion pictures showing cells elongating and breaking apart in the field of a centrifuge-microscope.

Dr. M. H. Jacobs, director of the Marine Biological Laboratory at Woods Hole, spoke on "Diffusion Processes in Living Systems." He referred to the great mystery of living organisms which can use diffusion to maintain and de-



THE UNIVERSITY OF PENNSYLVANIA MUSEUM, WHERE THE MEETINGS OF THE SYMPOSIUM WERE HELD

velop structure, although fundamentally diffusion is a process by which molecules pass by reason of simple probabilities from the organized to the unorganized. The major point of attack on the problem presented is on the vertebrate red blood corpuscle or erythrocyte. Dr. Jacobs referred to researches and results achieved on the behavior of their plasma membranes in passing or stopping materials of various kinds.

Dr. Herbert S. Gasser, director of the Rockefeller Institute for Medical Research, speaking on "Electrical Signs of Biological Activity," took as his principal example the behavior observed by means of electrodes within and without the surface films of nerve fibers. The sharp oscillographic spikes of potential detected indicate the mechanisms involved in nerve communications and have enabled the beginning of a theory of nervous activity to be set up which is proving very fruitful as a guide to further experimental work.

Dr. W. Mansfield Clark, of the Johns Hopkins Medical School, spoke on "Potential Energies of Biologically Important Oxidation-Reduction Processes." His paper was an excellent example of integrated fields of science as it was of interest in the three fields of biology, chemistry and physics. It considered the application of thermodynamics to the living cell, showing how this form of logic could often rule out conceivable mechanisms on the grounds of extreme improbability.

Dr. Francis O. Schmitt, of Washington University, speaking on "Optical Studies of the Molecular Organizations of Living Systems," referred to the necessity of understanding the configurations and orientations of the protein and lipoid molecules which go to make up living protoplasm. His paper dealt with studies of this problem using polarized light and x-ray diffraction analysis.

Dr. L. H. Germer, of the Bell Telephone Laboratories, spoke on "Electron Diffraction Methods of Studying Organic Films." This technique, important in the study of metallic and other crystalline surfaces, is applicable to thin biological materials. Dr. Germer described the techniques he has developed and indicated the fields of use and precautions to be observed.

Dr. Wendell M. Stanley, of the Rockefeller Institute for Medical Research, spoke on "The Biophysics and Biochemistry of Viruses." He referred to the declining view that viruses are living things, emphasizing their size and other properties which are characteristic rather of chemical molecules. He described recent researches in which, with the ultracentrifuge, the tobacco mosaic virus has been isolated in crystal form. This isolated substance constitutes material for researches which may lead to the practical production by purely chemical means of substances having immunizing properties.

Dr. Selig Hecht, of Columbia University, spoke on "Photochemistry of Vision." He traced the development of early ideas, their failure, owing to inadequate knowledge of photochemistry, and their present revival on the basis of better knowledge. His paper dealt with theories based on quantitative experiments on that stage in vision wherein light reacts with a sensitive element which, undergoing change, is enabled to activate optic nerve fibers.

Dr. Wallace O. Fenn, of the University of Rochester, spoke on "The Mechanics of Muscular Contraction." He described physical apparatus and mechanical reasoning which enable extensive studies of muscular mechanics to be made on living human subjects. The results indicate many of the properties of muscles as they vary under different conditions such as degree of extension. Such results must be useful in the study of the fundamental mechanism of muscular contraction.

Dr. L. A. DuBridge, of the University of Rochester, speaking on "Some Aspects of Nuclear Physics of Possible Interest in Biological Work," referred

DR. IRVING LANGMUIR
ASSOCIATE DIRECTOR OF THE RESEARCH LABORATORIES OF THE GENERAL ELECTRIC COMPANY.

principally to the neutron and to materials possessing induced radioactivity. The neutron rapidly imparts kinetic energy to the hydrogen atoms in biological materials, and these then produce intense local ionizations, different in density from that produced by beta rays, gamma rays or x-rays. The common elements, rendered radioactive, may have therapeutic value, but their greatest immediate use is in tracing the course of chemicals through biological processes.

The Saturday sessions of contributed research papers proved of no less interest than the invited papers referred to, large groups attending each of the sessions.

The symposium papers will be published for the most part in the *Journal of Applied Physics*, of which copies may be obtained from the office of the American Institute of Physics at 175 Fifth Avenue, New York. This symposium is the second of a series on fields of application of physics sponsored by the institute. The first dealing with physics in metals was held in January, 1937, at Cambridge, Mass. It is planned to hold another in the near future on physics as applied to automotive transportation.

H. A. BARTON

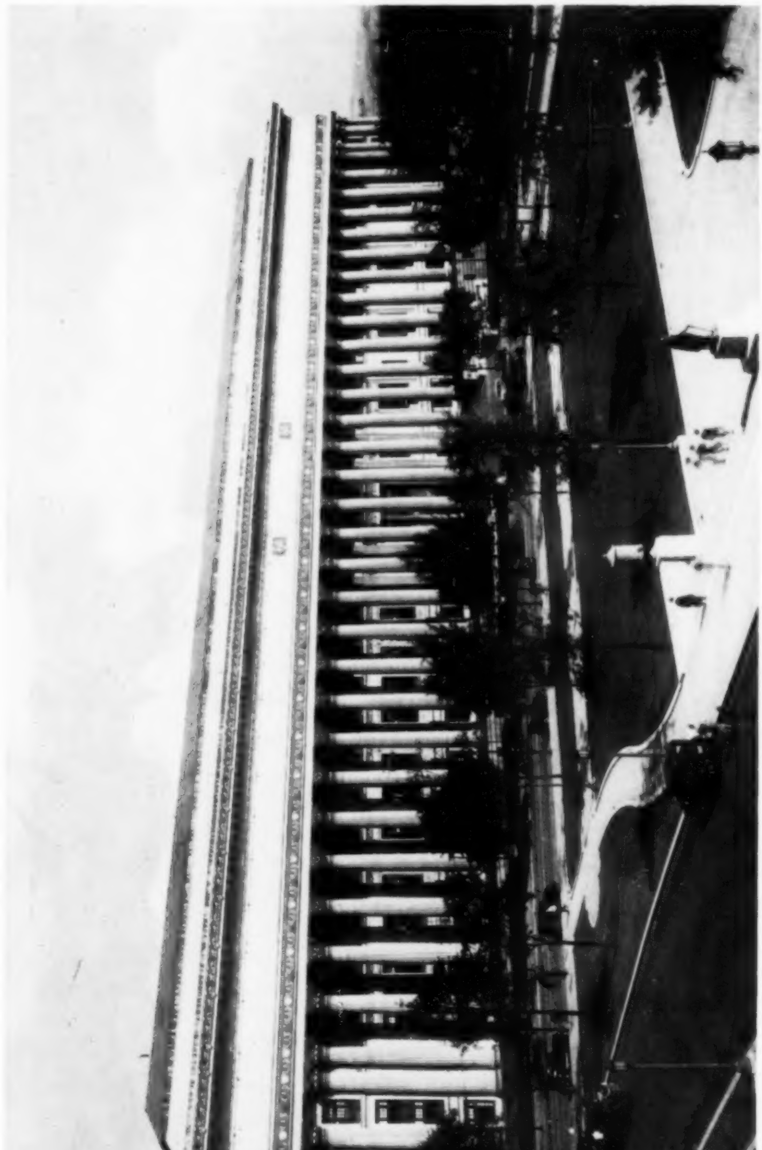
## THE CENTENARY OF THE NEW YORK STATE MUSEUM

On April 15, 1836, the Legislature of New York inaugurated a state geological and natural history survey. This developed one of the first inventories of the natural resources of any state, and thus New York was one of the first states to recognize that such scientific studies were a public function. It was at the same time the first scientific agency of the New York State government. The work of this agency, under various names, consolidations and enlarged functions, many years ago became officially known as the Division of Science and State Museum and is a part of the State Education Department at Albany.

The work of James Hall, John Torrey and their associates made a unique record for the early geology, botany and zoology of the state. Later the work accomplished by Dr. Asa Fitch, Dr. J. A. Lintner and Dr. E. P. Felt in entomology, Dr. Charles H. Peck for the fleshy fungi, Dr. John M. Clarke and Dr. Rudolf Ruedemann in paleontology, and Lewis H. Morgan and Dr. W. M. Beauchamp in Indian ethnology and archeology, has been outstanding. From its inception the institution has been primarily a research organization, and its extensive publications, both technical and popular, have been its major achieve-

JAMES HALL

GEOLOGIST OF THE STATE OF NEW YORK AND FIRST DIRECTOR OF THE NEW YORK MUSEUM. THE PHOTOGRAPH WAS TAKEN IN 1896 WHEN HALL WAS EIGHTY-FIVE YEARS OF AGE.



THE NEW YORK STATE EDUCATION BUILDING
IN WHICH ARE THE STATE MUSEUM AND THE DIVISION OF SCIENCE.

THE ZOOLOGY HALL OF THE NEW YORK STATE MUSEUM

ment. Notable exhibits have also been made. In normal times its exhibition halls are regularly visited by about 200,000 visitors, including thousands of pupils and students from schools and colleges.

With the passing of the years the field of activity has been expanded beyond that of the sciences to include the history and art of the state, although these fields have not been adequately developed.

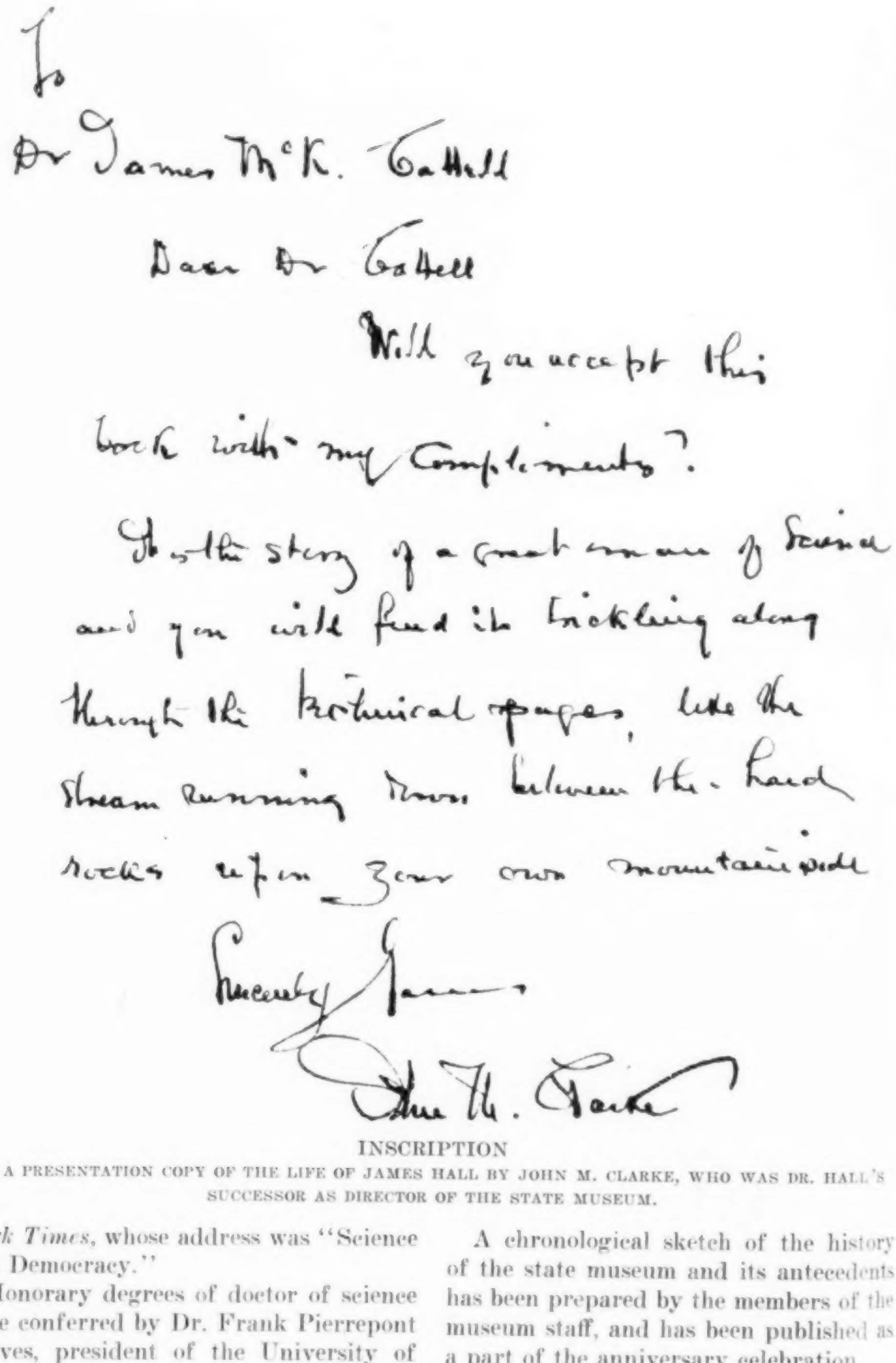
In commemoration of its centenary on April 15, 1936, the State Board of Regents decided to devote its seventy-third annual convocation on October 15, 1937, to this anniversary. The general theme of an anniversary has been aptly expressed by Dr. C. Stuart Gager as follows:

> But what is the point and purpose of recognizing an anniversary? . . . It is not so much to celebrate past achievement, but to reveal to the world the nature of the institution; for those in charge of it to clarify and possibly to restate their ideals in the light of the wisdom gained by past experience, and with a clear vision of future and larger accomplishments, made possible by new conceptions, new deeds, new methods and techniques, new resources and new enthusiasm.

In addition to this aim it was also intended to include emphasis on cultural, higher and synthetic values of science.

The speakers at the afternoon session were: Dr. John C. Merriam, president of the Carnegie Institution of Washington, whose address was on the "Influence of Science upon Appreciation of Nature"; Dr. C. Stuart Gager, director of the Brooklyn Botanic Garden, "The New York State Museum: One Hundred Years Young," and Lewis Mumford, author of "Technics and Civilization" and of a newly announced book, "The Culture of Cities," on "Regional Survey: Science for Citizenship."

The evening session was devoted to the relation of science to democracy. This was developed by Dr. Arthur E. Morgan, chairman, Tennessee Valley Authority, who spoke on "The Relation of Electricity to Social Policy," and Mr. Waldemar B. Kaempffert, science editor, *New*



To

Dr James McK. Cattell

Dear Dr Cattell

Will you accept this book with my compliments?

It is the story of a great man of Science and you will find it trickling along through the technical pages, like the stream running down between the hard rocks upon your own mountain side

Sincerely yours

John M. Clarke

INSCRIPTION

IN A PRESENTATION COPY OF THE LIFE OF JAMES HALL BY JOHN M. CLARKE, WHO WAS DR. HALL'S SUCCESSOR AS DIRECTOR OF THE STATE MUSEUM.

*York Times*, whose address was "Science and Democracy."

Honorary degrees of doctor of science were conferred by Dr. Frank Pierrepont Graves, president of the University of the State of New York, upon Dr. John C. Merriam, president of the Carnegie Institution, and upon Dr. Alexis Carrel, of the Rockefeller Institute for Medical Research.

A chronological sketch of the history of the state museum and its antecedents has been prepared by the members of the museum staff, and has been published as a part of the anniversary celebration.

CHARLES C. ADAMS,
*Director*

DIVISION OF SCIENCE AND
STATE MUSEUM

## THE WORK OF PROFESSOR SZENT-GYORGYI, RECIPIENT OF THE NOBEL PRIZE IN PHYSIOLOGY AND MEDICINE

Dr. Szent-Györgyi served in the Medical Corps of the Hungarian Army during the world war. After the war he became interested in biological oxidation and examined the various oxidation systems one by one in order to explain the reaction mechanism which was involved. A new oxidation system was brought to light when the adrenal gland was examined and subsequently a new and very interesting substance was shown to be present. Eventually this compound was isolated in pure crystalline form and was shown to possess the formula $C_6H_8O_6$. This same compound was then found to be widely distributed in nature, especially in the rapidly growing part of plants, such as lawn grass, the new shoots of grain, iris leaves, and so forth. The compound was named hexuronic acid, and a serious attempt was made to prepare sufficient amounts for its identification. This attempt brought Szent-Györgyi to the United States in the winter of 1929, at which time a quantity of hexuronic acid was isolated from adrenal glands at the Mayo Clinic, Rochester, Minnesota.

In 1930 Szent-Györgyi was appointed director of medical chemistry at the University of Szeged, Hungary. During the

PROFESSOR A. SZENT-GYÖRGYI

following years he carried on an investigation of the chemical and biological properties of hexuronic acid and in the spring of 1932 Szent-Györgyi and Svirbely established the fact that hexuronic acid was vitamin C. At the same time Dr. C. G. King and W. A. Waugh, of the University of Pittsburgh, showed that a crystalline compound which they had isolated from lemon juice and which was known to possess anti-scorbutic properties was identical with the compound hexuronic acid which had already been described by Szent-Györgyi. The identification of the chemical nature of vitamin C inaugurated innumerable investigations which have been concerned with the distribution and function of this important vitamin.

Szent-Györgyi found that the best natural source of vitamin C was the peppers grown in Hungary, and from this material several kilos of vitamin C were prepared in pure crystalline form. This enabled Haworth and Karrer to complete the identification of the vitamin, which in turn has permitted the development of methods for its synthetic preparation. It is now being prepared on a large scale from glucose.

Szent-Györgyi observed that some patients with purpura were relieved by the juice of peppers or of citrus fruits but not by pure vitamin C. Further investigation indicated that there is present in citrus fruits a second compound which has to do with the permeability of capillaries. This substance appears to belong to the family of flavons and has been named vitamin P from its relation to permeability. The symptoms of scurvy appear to be due to a lack of both vitamin C and vitamin P.

In addition to the work on vitamin C, Szent-Györgyi has carried on extensive studies in relation to the coenzyme involved in the oxidation of lactic acid and finally in regard to the significance of succinic, fumaric and oxalacetic acids in biological oxidations. The results of Szent-Györgyi and his coworkers have shown that these dibasic acids are involved in biological oxidation, probably as catalytic agents. One of the most surprising results of this work has been the observation that acidosis in patients with diabetes may be relieved by the administration of succinic acid.

E. C. Kendall

Mayo Foundation

## RETIREMENT OF DR. TOWNSEND FROM THE DIRECTORSHIP OF THE NEW YORK AQUARIUM

Dr. Charles Haskins Townsend retired as director of the New York Aquarium on November 1, 1937, completing thirty-five years in that capacity. He went to this institution from the U. S. Bureau of Fisheries when the New York Zoological Society took over the management of the aquarium, which had been a city-managed institution up to that time.

Under his guidance the aquarium has made great advances in the face of considerable obstacles. Originally the marine specimens were kept in the diluted and polluted water of New York harbor, the tanks were small, white-tiled affairs illuminated by gaslight, and the interior of the building was whitewashed. All this has been changed in these thirty-five years, in addition to which has been added a library and laboratories. The response of the public has been tremendous, and to-day the annual visitors number over two and one half million persons at an extremely low cost per visitor.

While all this has been going on, Dr. Townsend has been able to carry on his own particular researches. These in-

DR. CHARLES H. TOWNSEND
DIRECTOR OF THE NEW YORK AQUARIUM FROM 1902 TO 1937.

clude publications ranging from the migratory habits of whales to the color changes of which various fishes are capable. Since being at the aquarium, although expeditions were rather few because of obvious reasons, two trips were made to the Galapagos Islands in the interests of studies on the Galapagos tortoises, which have been threatened with extinction. Formerly Dr. Townsend spent much time in the field, having made world-wide cruises on the Bureau of Fisheries steamer *Albatross* as resident naturalist.

THE NEW YORK AQUARIUM

One of the results of this work was a thorough understanding of the Pribilof Island fur seals. His intimate knowledge of these animals caused him to be sent to The Hague when international negotiations were under way concerning the conservation of these then threatened animals. A very successful international treaty resulted therefrom and for many years this source of fur has been of great value to the persons and governments involved. He also is responsible in part for the successful commercial utilization of reindeer in Alaska.

The retirement of Dr. Townsend is really a misnomer, since it affects only his responsibility for the New York Aquarium. He will continue his studies on tortoises and whales and expects to expend most of his efforts in preparing a life-time of naturalist's notes for publication.

C. M. B.